Overview and Applications of the Integrated Approaches of Maintenance and Process Quality Control

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Abstract

Quality is becoming a business strategy leading to success, growth, and enhanced competitive position. Organizations with successful quality improvement programs can enjoy significant competitive advantages. With increasing automation and mechanization, production processes are shifting from workers to machines. Consequently, the role of equipment maintenance in controlling quantity, quality and costs are more evident and important than ever. To succeed in this new environment, equipment must be maintained in ideal operating conditions and must run effectively. This paper summarizes an overview of integrating statistical process control and maintenance by jointly optimizing their policies to minimize the total costs associated with quality, maintenance, and inspection. Based on the review of some typical new approaches and methods that were introduced, the advantages and disadvantages of these methodologies were discussed. Finally, a review of the literature, there has been some increased trends in the area of integrated research on maintenance and quality control.

Keywords

Quality Engineering, Maintenance Planning, Integrated System.

1. Introduction

For a long time, maintenance was difficult and expensive to support the product life cycle of any given system. Different methodologies have been inspected to reduce the number of failures or correct the failures of system historical ordinarily (Lorna Wong et al., 2010), by expanding the frequency of maintenance and support activities. Consistently improvement concept has been endeavored to overcome the challenges and difficulties confronted through maintenance of the past generation system. Generally, maintenance approaches have classified to two major classifications: Corrective maintenance (CM) is done after problem detection while preventive maintenance (PM) is carried out before problem detection; therefore corrective maintenance is done randomly while preventive is done frequently and regularly.

This paper summarizes a literature relating to specific issues of the integration of maintenance and quality control. Studies refer to readers interested in purely maintenance-related literature and design control charts by (Duncan, 1956), (Alexander et al., 1995), (Hassan et al., 2000), (Sherwin, 2000), (Wang, 2002), (Garg and Deshmukh, 2006), (Schiffauerova and Thomson, 2006), and (Nenes and Tagaras, 2007).

(Ben-Daya and Duffuaa, 1995) have stressed the need to link quality control and preventive maintenance. (Rahim, 1993) jointly determined the optimal design parameters on preventive maintenance time and an X control chart for a production system with an increasing failure rate. (Rahim, 1994), (Ben-Daya, 1999), and (Ben-Daya and Rahim, 2000) have attempted the integration of preventive maintenance and X-control chart when the process deteriorated during an in-control period following a general probability distribution with increasing hazard rate. (Cassady et al.,

2000) have studied the X-chart jointly with preventive maintenance policy based on age. (Yeung et al., 2007) have modified the model suggested by (Cassady et al., 2000) for using an X-chart to monitor the output of the production process and to determine when to perform corrective, condition-based maintenance so as to optimize the sample size, control chart parameters, and time to interval for performing PM. (Ben-Daya and Rahim, 2001) have provided an overview of the literature on integrated models of production, quality, and maintenance.

(Kuo, 2006) has studied the joint maintenance of the machine and the problem of product quality control of the limited horizon, discrete time, and the batch Markovian deteriorating production systems which could not be observed. (Linderman et al., 2005) have developed a general analytical model to determine the optimal policy for the coordination of statistical process control and planned maintenance to minimize the total expected cost. (Panagiotidou and Tagaras, 2007) have advanced an economic model for making the most optimization of the preventive maintenance of production process with two quality states. (Panagiotidou and Tagaras, 2008) have presented a developed economic model to make the most optimization of the maintenance policy, in order to perfect and imperfect maintenance actions, suitable for the production process (equipment) with two operating states ("in control" state and "out of control") and in statistical process control. (Chiu and Huang, 1996) have developed a model provides preventive maintenance in the economic design of control charts. They assumed distribution is not uniform for a period of in-control state with an increasing hazard rate and fixed sampling intervals. In addition, they assumed that the system will become as good as new after preventive maintenance procedures. (Zhou and Zhu, 2008) have merged the economic design of the control chart and maintenance management, and used the grid-search approach for developed a mathematical model to analyze the cost of the integrated model to find the optimal values of variables which are sample size (n) sample frequency (h), the width of control limit in units of standard deviation (L), and control limit coefficient (k), which reduces the expected cost per hour. Recently (Panagiotidou and Nenes, 2009) have suggested a model integrate of maintenance procedures and quality using Shewhart's control chart for variables. (Wang, 2011) has developed three models to maintain the manufacturing system, which is monitored by np control charts with respect to the time of interval sampling. (Pandey et al., 2011) have developed an integrated model for joint optimization of operational policies with regard to shop floor scheduling maintenance, quality control and production scheduling in a manufacturing system. First, the model for the integration of maintenance scheduling and decision-making which are related to quality control policies has been developed. Optimal periods of time have been provided for preventive maintenance and chart parameters to control that reduce the expected cost per unit time. Second, the integration of the optimal interval for preventive maintenance with the production schedule in order to determine the optimal sequence of the batch that will reduce the cost of the penalty incurred because of the schedule delay.

(Pandey et al., 2012) have developed an integrated model for joint optimization of preventive maintenance interval and control parameters incorporating the Taguchi loss function. The proposed model enables the determination of the optimal value of each of the decision variables, and preventive maintenance interval that minimizes the expected total cost of the integration per unit time. (Liu et al., 2013) have developed an economic and economic-statistical design of an X-control chart for two-identical unit series systems, the system is described using a five-state continuous-time Markov chain and the optimization model has been developed to find the optimal control chart parameters for minimizing the average maintenance costs. (Manavizadeh and Javan, 2014) have developed a joint optimization approach of maintenance planning, process quality, and production scheduling. The proposed model has been used CUSUM chart to control and improve the process quality and reduce the production defects. (Yin et al., 2015) have developed an integrated model of statistical process control and maintenance decision. The mathematical model is established to minimize the expected cost and optimizing the decision variables are fulfilled by using the genetic algorithm. (Shrivastava et al., 2016) have presented an integrated model for joint optimization of preventive maintenance and quality control policy with cumulative sum (CUSUM) control chart parameters. The proposed model enables the determination of the optimal value of each of the five decision variables, (n, h, k, tPM) and the decision interval (h1), that minimizes the expected total system cost per unit time. (Lu et al., 2016) have proposed a reliability model in which quality improvement is integrated into preventive maintenance decision-making. The quality loss is incorporated into the total cost, which is minimized to obtain the optimal PM schedule.

The objective of this section is to provide an overview of preventive maintenance and research quality control process through the past 17 years using bibliometric techniques. The goal is to show research the most productive and influential in the scientific community, according to information contained in the general databases that were considered, including Scopus and Google Scholar, Web of Science (WoS) and Science Direct. To focus on the main journal articles and reviews, the total number of publications found through the past 17 years has been 50 papers.

The information analysis is classified by articles per year, journals, authors, keywords, subject area, institutions, and countries. Finally, the major methods of the recent developments which are used for preventive maintenance and process quality control are presented. The aim of the descriptive analysis is to give a general view analysis of the selected articles in the previous phase.

1.1 The recent article analysis phase

The selected articles distributed in yearly time horizon to illustrate the trend of growth on the search topic. Notice, according to Figure 1, in the last years, there was a significant increase in the number of articles which have been published in the field of integrated preventive maintenance and quality control processes. Between 2000 and 2016 Nov., 50 articles were produced. In only two years from 2012 to 2013, the number of articles has reached nearly third the total. In addition, the citation number has reached to the maximum in 2012. In conclusion, the significant increase in the number of publications means there is a growth of integrated preventive maintenance applications and quality control processes.

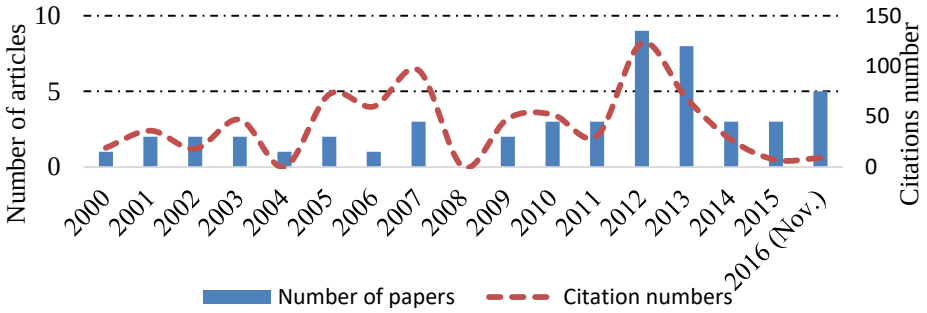

Figure 1. Articles published and their citation number per year

1.2 Journal analysis

In this aspect, 20 journals were counted. The first four journals obtained at least two records, representing almost a twenty six of all occurrences. Of the 26 occurrences, 23% is provided by both of European Journal of Operational Research (EJOR) and International Journal of Production Research (IJPR), 15% is provided by both of Industrial & Engineering Chemistry Research (IECR) and International Journal of Advanced Manufacturing Technology (IJAMY), and 62% is provided by other 22 journals. It is worth noting that, the impact factor is added to show the importance of each journal. The purpose of this analysis is to highlight the journals that focus on the research topic, as shown in Table 1.

Table 1. The publishing journals contributing to the research area

No.	Academic Journal		TP	IF	Paper References
1	EJOR	European Journal of Operational Research	3	2.679	(Liu et al., 2013, Kuo, 2006, Panagiotidou and Tagaras, 2007)
2	IJPR	International Journal of Production Research	3	1.693	(Pandey et al., 2012, Hui et al., 2001, Radhoui et al., 2009)
3	IECR	Industrial & Engineering Chemistry Research	2	2.567	(Ottavian et al., 2013, Ottavian et al., 2014)
4	IJAMY	International Journal of Advanced Manufacturing Technology	2	1.94	(Shrivastava et al., 2016, Rivera-Gomez et al., 2013)

5	AICHEJ	AICHE Journal	1	2.98	(Ge et al., 2013)
6	AJGP	American Journal Geriatric Pharmacotherapy	1	1.747	(Balkrishnan et al., 2003)
7	AJDAA	American Journal of Drug and Alcohol Abuse	1	1.88	(Wang et al., 2012)
8	ASE	Annals of Software Engineering	1	0.56	(Schneidewind, 2000)
9	AQU.	Aquaculture	1	1.893	(Erikson et al., 2012)
10	CR	Communication Reports	1	0.67	(Goodboy and Myers, 2010)
11	CS	Communication Studies	1	0.92	(McEwan and Guerrero, 2012)
12	CIE	Computers and Industrial Engineering	1	2.8	(Lu et al., 2016)
13	EUP.	Euphytica	1	1.54	(Beecher et al., 2012)
14	EJCN	European Journal of Clinical Nutrition	1	2.44	(Beberashvili et al., 2014)
15	FR	Family Relations	1	1.51	(Malinen et al., 2012)
16	HS	HortScience	1	0.72	(Robins et al., 2007)
17	IEEEJBHI	IEEE Journal of Biomedical and Health Informatics	1	2.75	(Saleh et al., 2015)
18	IEEETDEI	IEEE Transactions on Dielectrics and Electrical Insulation	1	1.67	(Yang et al., 2012)
19	IGIENE.	Igiene E Sanita Pubblica	1	0.19	(De Filippis et al., 2002)
20	ICCBR	International Conference on Case-Based Reasoning	1	0.302	(Zehraoui et al., 2003)
	Total		26		

Abbreviations: TP, is total papers of the journal; IF, is impact factor of the journal in 2016.

1.3 Author analysis

The author aspect was extracted with a frequency of appearance of those top selected articles. Only eight of the top 30 authors have contributed to more than one article, other authors appearing in only a single article. Table 2 outlines the most 30 contributing authors based on the number of published articles. It is worth noting that, the author's country and the total citations of listed articles in both Scopus and Web of Science databases are identified. Most productive authors are Rezg, N., Radhoui, M., Chelbi, A., Vrat, P., Matteo, O., Massimiliano, B., Salvador, G., and Gharbi, A. have gotten two articles for each one. It is observed that Francian and Chinese authors provide the most articles in the topic search. They followed by Italian and American authors. The analysis shows that the most cited article was published by Anderson, R.T. it has 32 citations, followed the articles which were published by both of Rezg, N., Radhoui, M. and Chelbi, A. they have gotten 29 citations in two articles for everyone. The purpose of this analysis is to highlight authors who spend good efforts on the research topic, as shown in Table 2.

Table 2. The top 30 contributing authors based on the number of published articles

No.	Author name	Country	TP	TC	No.	Author name	Country	TP	TC
1	Rezg, N.	France	2	29	16	Yang, J.	China	1	3
2	Radhoui, M.	France	2	29	17	Agha, M.H.	Pakistan	1	1
3	Chelbi, A.	France	2	29	18	Askarinejad, H.	Iran	1	1
4	Gharbi, A.	Canada	2	21	19	Anders, I.	Germany	1	0
5	Vrat, P.	India	2	9	20	Bartz, T.	Brazil	1	0
6	Matteo, O.	Italy	2	6	21	Kanawati, R.	France	1	0
7	Massimiliano, B.	Italy	2	6	22	Luo, YY.	China	1	0
8	Salvador, G.	USA	2	6	23	Park, HG.	S.Korea	1	0
9	Anderson, R.T.	USA	1	32	24	Park, YM.	S.Korea	1	0
10	Averbukh, Z.	Israel	1	15	25	Salotti, S.	France	1	0
11	Ankara, H.	Turkey	1	10	26	Siluk, JCM.	Brazil	1	0
12	Agabbio, M.	Italy	1	5	27	Xu, L.	China	1	0
13	Zhang, G.	China	1	3	28	Yang, MN.	China	1	0
14	Wang, Z.	China	1	3	29	Yan, M.	China	1	0
15	Wang, G.	China	1	3	30	Zehraoui, F.	France	1	0

Abbreviations: TC, is total citations.

1.4 Keyword analysis

Table 3 shows the most 38 popular keywords from the list of keywords. This is from a pool of 161 keywords drawn from the top selected papers. The three major keywords were "Predictive Maintenance", "Maintenance" and "Quality control" with around 28% of total articles, this is enhanced the relationship of a research study and the keywords.

Table 2. The most popular keywords

No.	Keyword	Frequency Word	No.	Keyword	Frequency Word
1	Predictive Maintenance	21	20	Maintenance Quality	3
2	Maintenance	13	21	Mental Health	3
3	Quality control	11	22	Middle Aged	3
4	Article	6	23	Prediction	3
5	Human	6	24	Probability Distributions	3
6	Humans	6	25	Quality	3
7	Optimization	6	26	Quality Assurance	3
8	Female	5	27	Relational Maintenance	3
9	Male	5	28	Adult	2
10	Aged	4	29	Algorithms	2
11	Major Clinical Study	4	30	Buffer stock	2
12	Quality Of Life	4	31	Comparative Study	2
13	Reliability	4	32	Condition Monitoring	2
14	Repair	4	33	Control Parameters	2
15	Treatment Outcome	4	34	Controlled Study	2
16	Aged, 80 And Over	3	35	Corrective Maintenance	2
17	Equipment	3	36	Costs	2
18	Failure Analysis	3	37	Cross-Sectional Studies	2
19	Imperfect Preventive Maintenance	3	38	Cross-sectional Study	2

1.5 Subject area analysis

The top selected articles were classified into 19 subject areas as shown in Figure 2. This highlights the interdisciplinary nature of research area. The two major contributors were "Engineering" and "Computer Science" with around 40% of total articles. These followed by "Decision Science" and "Medicine" with almost 14% of the total articles. Other subject areas were poor with very little change in the frequency through time.

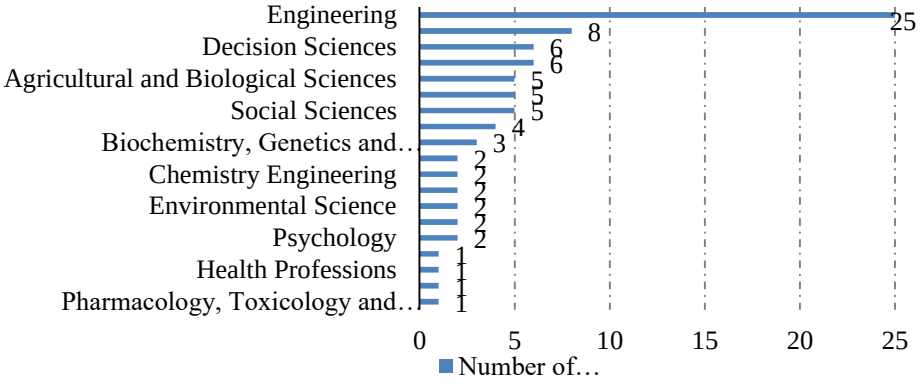

Figure 2. Number of publications per research area

1.6 Country analysis

Figure 3 describes observed that of the top articles analyzed, 29 were written by researchers linked to the institutions of the USA, China, Canada, India, and Italy. These five countries contribute 58 percent of observed published articles in this study. The USA is in the top of the list with 11 articles. The purpose of this analysis is to highlight countries focus on the research topic.

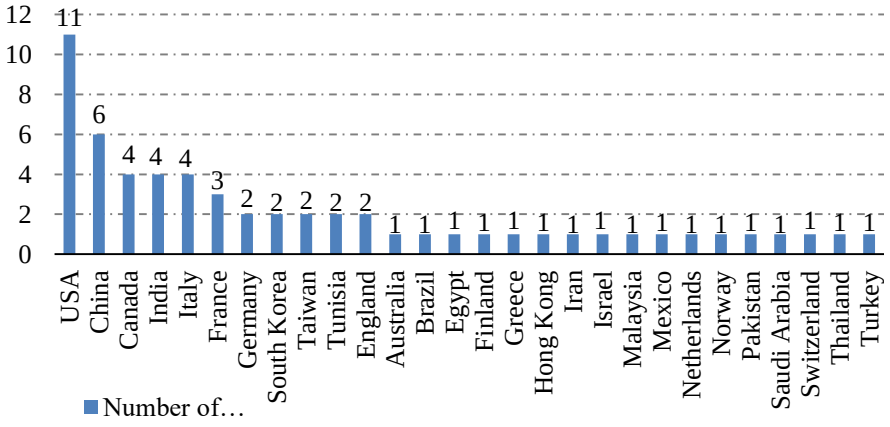

Figure 3. Number of publications per country

1.7 Organization analysis

The top 20 contributing organizations based on the number of published articles are shown in Table 3 which is displayed that these organizations have attracted research centers from around the globe. The top six ranks in author organization are Chongqing University, Indian Institute of Technology Delhi, Lgipm, Pfizer Inc., University De Tunis and University Degli Studi di Padova with articles occupying 24% of the total published articles.

Table 3. The top 20 contributing organizations based on the number of articles

No.	Organization	Country	TP	No.	Organization	Country	TP
1	Chongqing University	China	2	11	Balfour Beatty Rail GMBH	Germany	1
2	Indian Institute of Technology Delhi	Indian	2	12	Bloomsburg University	USA	1
3	LGIPM	France	2	13	Cairo University Faculty of Engineering	Egypt	1
4	Pfizer Inc.	USA	2	14	Case Western Reserve University	USA	1
5	University DE Tunis	Tunisia	2	15	Centre National DE LA Recherche Scientifique CNRS	Canada	1
6	University Degli Studi DI Padova	Italy	2	16	Centro Internacional DE Mejoramiento de Maiz y Trigo	Mexic	1
7	Anadolu University	Turkey	1	17	Chinese University of Hong Kong	China	1
8	Andong National University	South Korea	1	18	City University	England	1
9	Aristotle University of Thessaloniki	Greece	1	19	Dalian University of Technology	China	1
10	Aston University	England	1	20	Ecole DE Technologie Superieure	Canada	1

1.8 Major methods of the recent developments used for preventive maintenance and quality processing papers.

In this section, the recent and new applications of preventive maintenance and process quality control are presented which are reported in the literature after the year 2000. It is worth noting that, only the real case applications are displayed as shown in Table 4.

Table 4. Applications of the recent preventive maintenance and process quality control articles

Category	Methods	Supportive techniques	Application domains	Advantages	Disadvantages	References
An optimization model	An integrated model (corrective, preventive maintenance and quality models)	Quality policy incorporating Taguchi loss function	A single component operating as a part of a machine	A general model without the need for recollecting data	Component/ part specialty, hard to apply on a system	(Pandey et al., 2012)
An optimization model	An integrated model (corrective, preventive maintenance and quality models)	Quality control policy parameters with CUSUM chart	A single component operating as a part of a machine	A general model without the need for recollecting data	Component/ part specialty, hard to apply on a system	(Shrivastava et al., 2016)
An optimization model	An integrated model	Conditional reliability of the components	A production unit having n components	A model can be applied to a wide variety of manufacturing equipment	Model is needed to modifications if it applies to a variety of manufacturing equipment	(TAMBE et al., 2016)
An optimization model	Economic and economic-statistical designs	Continuous time Markov chain, $\bar{X}$ control chart	Two-unit series systems	A general model without making much specific assumptions	Two-unit series systems specialty, hard to apply on other systems	(Liu et al., 2013)
An optimization model	An integrated reliability model	Proportional hazard model	Single-machine manufacturing systems	A model can integrate quality improvement into PM decision-making	A model cannot make the integration of maintenance and quality improvement for the multi-station manufacturing systems.	(Lu et al., 2016)
An optimization model	A dynamic programming model, Joint maintenance and quality control policy	A Markov decision process	Production machine	Might be used for different operating conditions without the need for recollecting data	Model cannot able to implement for different size units	(Kuo, 2006)
An optimization model	An integrated model	A Tabu Search Algorithm	Process manufacturing a single item	A general model without making much specific assumptions	Model re-training is needed if operating conditions change	(Rahim and Shakil, 2011)
A scheduling model	An Integrated Methodology	Regression and simulation models	Production line	A schedule can implement to reduces breakdowns and increases the production line's availability	Data and statistical The analysis is needed to update every time, failures of each machine are needed to more detail to the component level	(Smadi, 2011)
A mathematical model	A sequential PM policy	A genetic algorithm, maximal cumulative-hazard strategy	Degradation system with a finite lifetime	A model can describe the randomness and trend of the PM quality and makes the optimization results more robust	Model has some restrictions, such as how to set up the relationship between the reduction factor and the corresponding PM cost	(Liu et al., 2011)
A mathematical model	An integrated model	Simulation model	Single production machine	A model can be applied for production system which is producing conforming and nonconforming units	Single machine specialty, hard to apply on a system	(Radhoui et al., 2009)

2. Conclusion

In this paper, an overview on the integrated approaches to maintenance and process quality control has been presented through the past 17 years using bibliometric techniques. The goal is to show research the most productive and influential in the scientific community, according to information contained in the general databases that were considered through the famous scientific research engines. To focus on the main journal articles and reviews, the total number of publications found through the recent years, were at last 26 papers are specializing in this field. The information analysis is classified by articles per year, journals, authors, keywords, subject area, institutions, and countries. Finally, the paper concludes with an overview of applications of the recent developments which are used for preventive maintenance and process quality control for giving a descriptive analysis and a general view analysis of the selected articles published in the previous phase.

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