Review of Reliability Centered Maintenance on High Productivity Machines using Case-Based Reasoning and Rule Based Reasoning with AI RCM Agent

Mr. K Naresh Raj, Dr. NYS Raju

Abstract-: Reliability Centered Maintenance on high productivity machines in terms of machine wise and component wise using Case-Based Reasoning and Rule Based Reasoning for Reliability assessment with the AI RCM Agent. In this context AI (Artificial Intelligence) RCM Agent i.e., tool correlate with the all segments of machines for developing Automated Maintenance plan. The process involves Initially define RCM Agent, preparation of Algorithm, preparation of Artificial Intelligence model by CBR, RBR. This is done mathematically and computerized to generate effective and efficient maintenance plan for maintenance department which possess high sensitivity.

keywords: RCM (Reliability Centered Maintenance), AI (Artificial Intelligence) model, CBR (Computer Based Reasoning), RBR (Rule Based Reasoning),Machine-learning(ML).

I. INTRODUCTION

RCM is a preventive maintenance tool which is known as reliability centered maintenance. This RCM analysis consists of Reliability, maintainability, Availability Evaluations. After that FMEA (Failure Mode Effect Analysis), Repairs Analysis (RA), Replacement Analysis(RPA), Cost Analysis (CA) RCM (Reliability Centered Maintenance), AI (Artificial Intelligence) model, CBR (Computer Based Reasoning), RBR (Rule Based Reasoning),Machine- learning(ML).Till this already lots of research had been accomplished based On Industrial revolution 4.0 for versatile applications. Even with optimistic strategies' comparative studies had been accomplished, but in this paper inclusion of optimistic approach for Optimization, Effectiveness' and Efficient Maintenance Plan.

II. LITERARTURE REVIEW

Zhonghua Cheng & Xisheng Jia introduces intelligence on Reliability centered maintenance by publishing paper "An Intelligent Reliability Centered Maintenance Analysis system Based on Case- Based Reasoning & Rule -Based Reasoning "in 2005[1] in this paper (AI) technologies, such as case-based reasoning (CBR) and rule- based reasoning (RBR), were successfully introduced into RCM analysis process, and an intelligent RCM analysis system (IRCMAS) based on CBR and RBR was developed to aid RCM analysts. The idea for such an intelligent system is based on the fact that the historical records of RCM analysis on similar items can be referenced and used for the current RCM analysis of a new item. The application of the IRCMAS reduces the skill requirement of RCM analysts, shortens the development period of RCM program, and therefore enhances the cost-effectiveness of RCM process. The IRCMAS is substituting the traditional computer aided RCM system (CARCMS) within China's military industry, and is becoming the new generation RCM analysis tool for weapon systems under development[1].

Zhonghua Cheng , Xisheng Jia, Ping Gao, Su Wu, Jianzhao wang published research paper "A framework for intelligent reliability centered maintenance analysis" in 2008[2]. To improve the efficiency of reliability-centered maintenance (RCM) analysis, case-based reasoning (CBR), as a kind of (AI) technology, was successfully introduced into RCM analysis process, and a framework for intelligent RCM analysis (IRCMA) was studied. The idea for IRCMA is based on the fact that the historical records of RCM analysis on similar items can be referenced and used for the current RCM analysis of a new item. Because many common or similar items may exist in the analyzed equipment, the repeated tasks of RCM analysis can be considerably simplified or avoided by revising the similar cases in conducting RCM analysis. Based on the previous theory studies, an intelligent RCM analysis system (IRCMAS) prototype was developed. This research has focused on the description of the definition, basic principles as well as a framework of IRCMA, and discussion of critical techniques in the IRCMA. Finally, IRCMAS prototype is presented based on a case study[2].

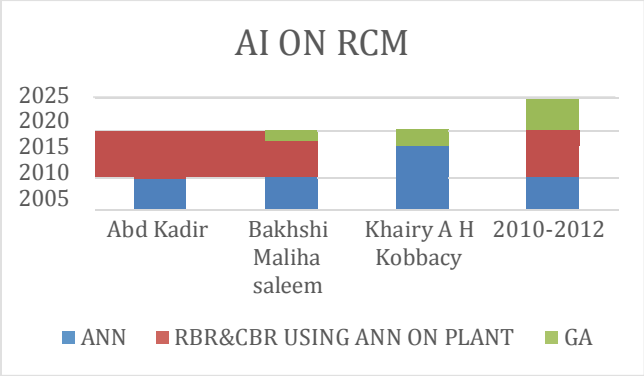
SLNO	NAME	RESEARCH	YEAR
1	Zhonghua Cheng & Xisheng Jia	Artificial Intelligence had been introduced on RCM	2005
2	Zhonghua Cheng & Xisheng Jia	Artificial Intelligence on RCM is Case based and Rule Based	2008

Abd Kadir Mahamaad, Sharifah Saon, Takashi Hiyama published research paper on 2010 i.e.," Predicting remaining useful life of rotating machinery based artificial neural network"2010[3].this paper includes Accurate remaining useful life (RUL) prediction of machines is important for condition based maintenance (CBM) to improve the reliability and cost of maintenance. This paper proposes artificial neural network (ANN) as a method to improve accurate RUL prediction of bearing failure. For this purpose, ANN model uses time and fitted measurements Weibull hazard rates of root mean square (RMS) and kurtosis from its present and previous points as input. Meanwhile, the normalized life percentage is selected as output. By doing that, the noise of a degradation signal from a target bearing can be minimized and the accuracy of prognosis system can be improved. The ANN RUL prediction uses FeedForward Neural Network (FFNN) with Levenberg Marquardt of training algorithm. The results from the proposed method shows that better performance is achieved in order to predict bearing failure.[3]2010

Bakhshi Maliha Saleem, Muhammad Aslam, Martinez-Enriquez A.M, Escalada-Imaz G These Authors published paper "**A hybrid system for reliability centered**

maintenance" 2011[4]. Reliability centered maintenance provides failure free functionality of heavy plant equipment. Tedious preventive maintenance tasks, inapplicable solutions and significant startup costs are the major limitations of this strategy. The aim of this paper is to improve the analysis efficiency of reliability centered maintenance without trading off quality by its integration with artificial intelligence. In order to achieve key performance indicators for the plant management, we incorporated rule-based reasoning along with the case-based reasoning. While only case-based technique was introduced previously, our approach reduces repetitive tasks and also provides support in predicting equipment needs, by applying artificial neural networks[4]

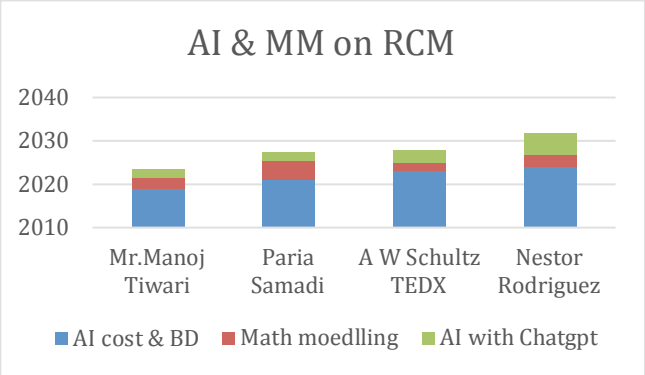
Khairy A H Kobbacy he published research paper "Application of Artificial Intelligence in Maintenance Modelling and Management" volume 45 issue 31 2012[5] he : Over the past 3 decades many attempts have been made to apply Artificial Intelligence (AI) techniques in maintenance modeling and management. Essentially the use of AI is an attempt to replace human intelligence with machine intelligence. The ultimate objective is to achieve more effective maintenance management and in some cases to make achieving this goal a viable option. The AI techniques used are numerous ranging from the classic expert systems that utilizes rule based reasoning to the more cumbersome optimization techniques used in Genetic Algorithms. Over the past decade there has been a shift towards developing hybrid intelligent management systems in operations that use more than one AI technique. The application areas of AI in maintenance extends widely from the intelligent maintenance optimization models to the more practical applications such as cost budgeting of maintenance projects and selecting optimal repair methods. This paper presents an overview of the applications of AI techniques in maintenance over the past decades identifying specific applications and extent of use of techniques. The paper discusses the applications of AI techniques and recent trends.[5]



Mr. Manoj Tiwari, Mr. Malkaus Chaudhary published research paper on "Development and implementation of reliability centered maintenance (RCM) system using artificial intelligence**" in June 2019[6].** Global apparel manufacturing is becoming more competitive with each day. Effective and efficient utilization of resources has become vital for to survival. Cost optimization is the key to remain competitive and profitable in this scenario. Machine and equipment maintenance is one of the major factor contributing in the success or failure of any manufacturing organization. The issue of machine breakdown is very critical in apparel manufacturing which leads to delay in manufacturing and eventually results in various types of losses. This research aims at reducing the downtime of the plant machinery by implementing a planned preventive maintenance program through the application of the Reliability Centred Maintenance using Artificial Intelligence. The traditional approach of planned preventive maintenance is based on the calendar which doesn't take due consideration of machine behaviour and failure patterns; hence it lacks reliability. Therefore, this research proposes a system which can learn the nature and frequency of defects on the bases of the machine types. Subsequently, a Reliability Centred Maintenance programme is devised ensuring improved availability of the machines, and resulting into reduced machine breakdown and failure. The approach discussed in this research paper is based on the deep learning model to learn the defects and its analysis with help of a database created as per specific requirements of an apparel manufacturing environment. Initial data grasping of the machine breakdowns on floor was done to understand the nature of the problems. To understand the problem more accurately the nature of frequent machine breakdown as well as frequency of the breakdowns were recorded from thirteen sewing lines from three sewing floors. The machine breakdown data was collected for each of the sewing machines of different types from the selected lines of a sewing floor. The data was categorized as per the type of machine and number of machines. Month wise data related to machine breakdown occurrence, machine breakdown time and major defects frequency was collected before and after system implementation. A significant improvement was observed in all the aspects studied as approximately 29% reduction in machine breakdown, 35% reduction in defects occurrenceand15% reduction in the machine breakdown time was observed after system implementation. This approach also resulted in creating an environment of learning organisation which learns about itself as the system grows with the organization.[6]

Paria Samadi-Parvinejada published research paper , "Development of a mathematical model of preventive maintenance by increasing reliability and reducing cost" Vol. 1, No. 2, (2021), [7].this paper is abouty, in large production organizations of the world and factories that have a lot of complex equipment and machines, creating a coherent and efficient maintenance and repair system with a favorable response speed is one of the most important factors in order to improve the performance level of production processes in order to compete and reduce costs. In today's world, the need for industries to produce high-quality products at reasonable prices in order to increase the ability to compete in the market has caused the use of preventive maintenance and repair systems to flourish. In this regard, periodic preventive repairs and replacements should be used as the most effective solution to reduce breakdowns. This research tries to determine the effect of fixed cost in determining the repair and replacement of components in the preventive maintenance system. Also, by using the meta-heuristic algorithm (GA, genetic algorithm), it will be discussed to express the existence of a high percentage of reliability with a budget limit, as well as cost reduction without reducing the reliability factor. By developing a mathematical model and paying attention to the existence or non- existence of fixed cost, the appropriate solution among the three methods of repair and replacement or nothing is determined in the preventive maintenance system. By using meta-heuristic techniques, steps are taken in order to reduce the cost without changing the reliability[7]

A.W.Schultz TEDx speaker Industry 5.0 Knowledge(Consultant) Reliability Centered Maintenance(Author/Trainer) he published a paper on "Harnessing the Power of Open AI in Reliability-Centered Maintenance "on May 10 2023[8]. Change of cause: I had a recent experience with a client who needed to schedule a lot of maintenance tasks for a new assembly line. Initially, we tried categorizing similar equipment or using the original operation manuals as a starting point. However, one planner shared their method of creating hundreds of maintenance tasks using AI in just a few hours. Although AI is a commonly used term nowadays, it's important to be aware of its limitations and potential benefits. I'm writing this article to discuss the role of Open AI in improving equipment reliability and enabling predictive maintenance for optimal performance. How to use AI: I currently use two types of AI. One I pay for, and the other one is now Free. Texta.ai helps generate content; however, they have limitations. The second one is ChatGPT; This AI is a chatbot that allows you to ask a question, and it will answer. The individual who shared this with me was asking ChatGPT to write a maintenance PM, which generated the PM for him. At this point, you might be jumping on one side or the other side of the fence; however, if using AI, you need to understand a couple of rules. The first is written at the bottom of the site. Which reads," ChatGPT may produce inaccurate information about people, places, or facts." This is true. In general, you can think of AI as a Swiss Army Knife. It's generally good but not the best in any tool.[8]



Nestor Rodriguez-Padial,Marta M.Marin,Rosario Domingo authors published research paper on "Improvement of Industrial Maintenance Plans through Assistance-Driven Reliability-Centered Maintenance and Case-Based Reasoning Design" on **3 February 2024[9]** This paper includes The present work builds on studies where the industrial market is currently characterized by a highly variable demand in terms of the quantities and flexibility of manufacturing or mass customization, which translates into a more demanding production context in terms of the continuous changes that are required in the production systems, the effect of which results in an increase in the fatigue of the machines that make up the production systems.

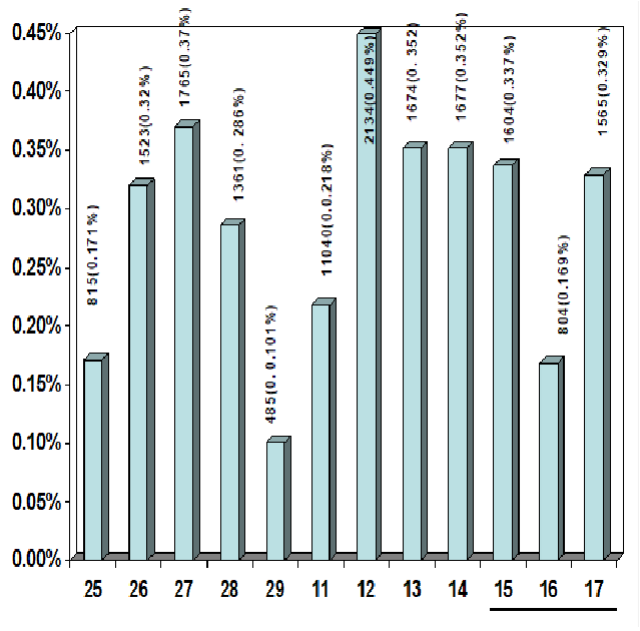
However, current production systems tend to use highly communicative and sensorized cyber–physical systems; these characteristics can be used to integrate them into decision- assisted systems to improve the availability of the industrial plant. The developed assisted system focuses on collecting and taking advantage of historical knowledge of industrial plant failures and breakdowns. By ideally integrating the reliability-centered maintenance (RCM) methodology and case-based reasoning (CBR) algorithms implemented in a Java application, it is possible to design maintenance plans that are adjusted to the real and changing operational context of any industrial plant. As a result, faster and more accurate decisions are made, because they are based on data. This article focuses on improving certain aspects of the developed assisted system by adding more value by incorporating fuzzy logic (FL) techniques.

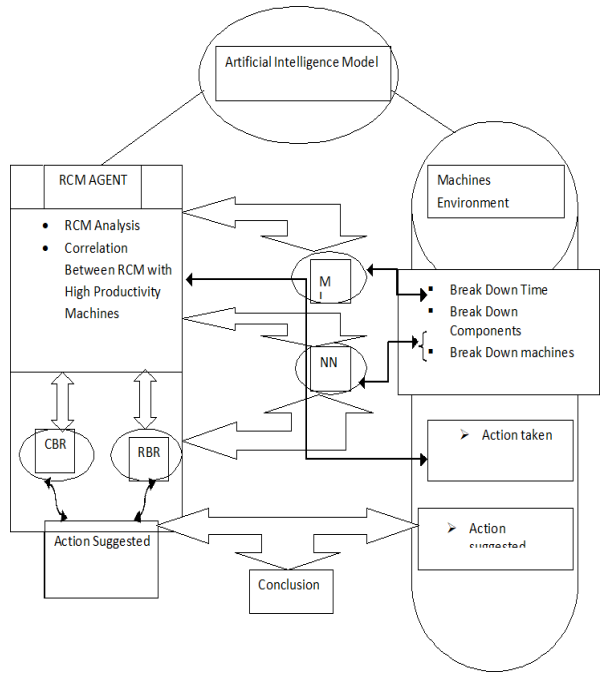
The aim is to improve the way of entering information about risk factors and their relative importance by incorporating natural language instead of a numerical score, resulting in increased precision in the calculation of the risk priority number (RPN) of the new cases that are incorporated into the assisted system. On the other hand, an attempt has been made to correct two of the main inherent and recognized weaknesses in the classic RPN calculation method by implementing an appropriate mix of fuzzy logic techniques.[9]

INDUSTRY PROFILE AND DATA COLLECTED OF AUTOMATED MACHINES BREAK DOWN OF 2023-24

25	765	160	740	150	560	820	385	315	170	400	360
26	575	95	375	120	350	100	105	560	550	165	20
27	225	110	165	175	185	945	120	390	0	0	640
28	2020	325	1675	440	775	1675	490	490	390	300	85
29	595	260	180	755	260	4420	590	590	430	100	385
11	585	20	365	900	735	230	800	810	670	305	700
12	535	300	405	430	1005	350	645	1100	550	350	420
13	510	135	3360	400	140	380	45	800	190	0	1930
14	485	165	235	615	480	260	250	640	310	50	545
15	750	80	335	405	235	475	280	850	420	20	235
16	1225	40	150	660	355	295	320	380	245	245	0
17	1505	205	1030	1390	530	505	145	1080	900	135	225
TOTAL	9775	1835	9015	6450	5610	6455	4175	8070	4825	2070	5545

Machines break down from jan 09 to nov 09 2023-2024





PROJECT ALGORITHM

SUMMARY

From references [1],[2], the research had been initiated on Reliability Centered Maintenance Through Artificial Intelligence, then From [3],[4],[5] the research been held on RCM by ANN (Artificial Neural Networks), RBR (Rule Based Reasoning), CBR (Case Based Reasoning) and GA (Genetic Algorithm). From [6],[7],[8] research on RCM has been in era of AI(Artificial Intelligence) for Reduction in Breakdown and Cost reduction, Mathematical Modelling using GA and AI with Chat GPT. This type of research had been down which is mentioned in above context. And in last from [9] the AI on RCM is by using CBR algorithm in java of Fuzzy logic. This is all sorts of research held till 2024 from 2005 it means from two decades. But from my review my research will be Integration of above references with AI RCM Agent on High productivity machines to generate Effective, Efficient and Optimized Maintenance Plan.

CONCLUSION

AI RCM agent is a maintenance tool that applicable for all types of engineering systems. Especially for mechanical machines.

Methodology of this tool is to generate maintenance plan by performing analysis like maintenance, FMEA on the machines/systems. Today the question „is rcm is effective enough to serve the maintenance engineer who belongs to small and medium scale firms is increasingly being asked. Continual modernization and the pressing need for higher and higher productivity have resulted in the increased development and use of sophisticated & complex machines and equipment's. This has resulted in increased capital employed in production equipment (waeyenbergh & pintelon, 2002). Systems are also becoming less sensitivity to their operation & support. In case of reasoning advancement process and various other plants, which are one-off and cannot be prototype tested, incipient failures occur. This affects production and resulted in= loss of revenue. Till now AI RCM Agent tool worked as technique which generates effective maintenance plan for limited and low-level equipment. Addition of managerial approach to this AI RCM Agent tool in order to restrict the loss of sensitivity or operations and support to the machineries with application computerized based reasoning i.e case-based reasoning (CBR) and Rule Based reasoning (RBR) of advancement and to generate effective maintenance plan in economical manner. This is achieved by performing generation of algorithm integrating AI RCM Agent with operational and support bodies of machineries using machine-learning, computer-based reasoning. And prime focus of analysis is on the elements of machines which give more effective and efficient result.

REFERENCES

[1]. Zhonghua Cheng & Xisheng Jia "An Intelligent Reliability Centered Maintenance Analysis System Based on Case-Based Reasoning & Rule -Based Reasoning". IEEE 2005.

[2]. Zhonghua Cheng & Xisheng Jia "A framework for intelligent Reliability Centered Maintenance analysis" IEEE 2008.

[3]. Abd Kadir Mahamaad, Sharifah Saon, Takashi

Hiyama "Predicting remaining useful life of rotating machinery based artificial neural network".2010.

[4]. Bakhshi Maliha Saleem, Muhammad Aslam, Martinez- Enriquez A.M, Escalada-Imaz G **"A hybrid system for reliability centered maintenance". 2011**.

[5]. Khairy A H Kobbacy "Application of Artificial Intelligence in Maintenance Modelling and Management". volume 45 issue 31 2012.

[6]. Mr. Manoj Tiwari, Mr. Malkaus Chaudhary "Development and implementation of reliability centered maintenance (RCM) system using artificial intelligence**" in June 2019.**

[7]. Paria Samadi-Parvinejada "Development of a mathematical model of preventive maintenance by increasing reliability and reducing cost" Vol. 1, No. 2, (2021)

[8]. A.W.Schultz TEDx speaker Industry "Harnessing the Power of Open AI in Reliability-Centered Maintenance "on May 10 2023.

[9]. Nestor Rodriguez-Padial,Marta M.Marin,Rosario Domingo "Improvement of Industrial Maintenance Plans through Assistance- Driven Reliability-Centered Maintenance and Case-Based Reasoning Design" on **3 February 2024**

AUTHORS

Mr. K NARESH RAJ ,2201203014, PhD Research Scholar, JNTUH Kukatpally, Hyderabad.

Dr. NVS RAJU, Principal of University College of Engineering Wanaparthy, Professor in JNTUH University College of Engineering Science & Technology Hyderabad.