International Journal of Modern Communication Technologies & Research (IJMCTR)
ISSN: 2321-0850, Volume-12, Issue-1, January - June 2024

A Review of Reliability Centered Maintenance on High Productivity Machines with Comparison of Topsis

Mr. K NARESH RAJ, Dr. NVS RAJU, K REVANTH

Abstract-: Preventive Maintenance is Most Sustainable that's why Reliability Centered Maintenance preventive maintenance tool had been Inclusively widely used for applications in industries in various segment's versatile way in order to obtain optimistic, effective, and efficient maintenance of machines till date i.e Industrial Revolution 4.0 .in this context lots of research had been accomplished based on applications but still to go because of applications scope. Reliability Centered maintenance is purely based on application of system specifications, operational conditions, repairs, replacements, Cost Analysis (CA), Failure Mode Effect analysis (FMEA) including comparative conclusion with Mathematical Technics like TOPSIS (Technique for order preference by similarity to Ideal Solutions).not only this every instant analysis of machines Accomplishment for maintenance Plan.

key words— RCM (Reliability Centered maintenance), FMEA on Repairs and Replacements, Cost Analysis, TOPSIS Mathematical Technique

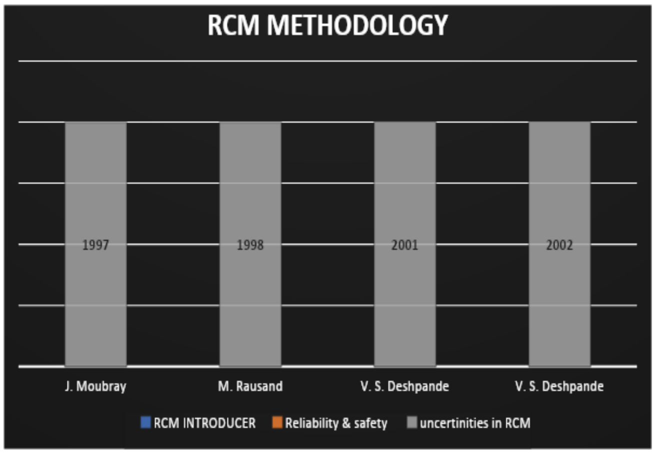
INTRODUCTION

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). Till this already lots of research had been accomplished basedOn 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.

LITERARTURE REVIEW

J. Moubray Introduces "Reliability Centered Maintenance" in (1997) he published This book provides a comprehensive guide to the principles and applications of Reliability-Centered Maintenance (RCM). It covers the RCM methodology, emphasizing its role in improving the reliability and cost-effectiveness of maintenance programs. The book addresses the implementation process, benefits, and challenges associated with RCM.[1]. *M. Rausand published paper on "Reliability Centered Maintenance" in Reliab Eng Syst Saf (1998) This paper reviews the principles and methodologies of Reliability-Centered Maintenance (RCM). It discusses the process of determining appropriate maintenance tasks based on system reliability and safety requirements. The paper also highlights the benefits of RCM in optimizing maintenance strategies and improving system performance [2].V. S. Deshpande published paper on "Modelling of uncertainties in reliability centered maintenance: probabilistic approach" (2001)This paper presents a probabilistic approach to model uncertainties in Reliability-Centered Maintenance (RCM). It focuses on incorporating uncertainty into the decision-making process for selecting maintenance tasks. The proposed method aims to enhance the reliability and cost-effectiveness of maintenance activities by considering the probabilistic nature of system failures and maintenance actions [3].

V. S. Deshpande published paper on "Application of RCM to a medium scale industry" Reliab Eng Syst Saf (2002) it is a case study explores the application of Reliability-Centered Maintenance (RCM) in a medium-scale industry. It discusses the implementation process, challenges faced, and the outcomes achieved. The study demonstrates how RCM can be effectively utilized to improve maintenance practices and enhance the reliability and availability of industrial equipment [4].V. S. Deshpande published same scenario but application on plant "Application of RCM for safety considerations in a steel plant" Reliab Eng Syst Saf (2002)[5]



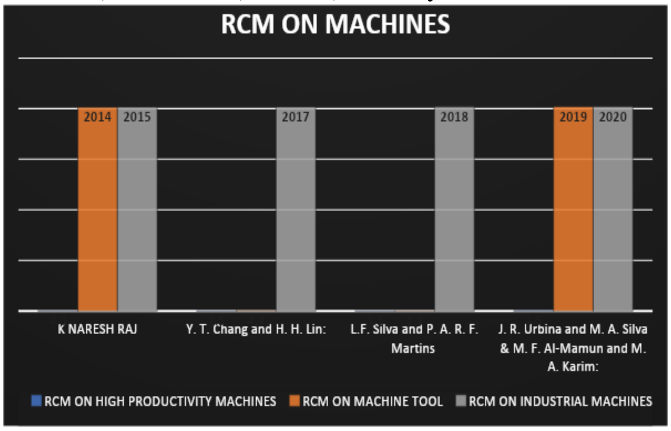
Xiaojun Zhou published research paper on: "Reliability centered predictive maintenance scheduling for a continuously monitored system subject to degradation" Reliab Eng Syst Saf (2007) This paper presents a predictive maintenance scheduling approach based on Reliability-Centered Maintenance (RCM) for systems subject to degradation and continuous monitoring. The proposed method integrates condition monitoring data with RCM principles to optimize maintenance schedules, aiming to improve system reliability and reduce maintenance costs.(2007)[6]

Gang Niu published research paper on "Development of an optimized condition-based maintenance system by data fusion and reliability-centered maintenance "in Reliab Eng Syst Saf (2010)This paper discusses the development of an optimized condition-based maintenance (CBM) system using data fusion techniques and Reliability-Centered Maintenance (RCM) principles. The proposed system integrates multiple data sources to enhance the accuracy of condition assessments and optimize maintenance decisions, resulting in improved system reliability and reduced maintenance efforts (2010)[7].

SLNO	NAME	RESEARCH	YEAR
1	Xiaojun Zhou	RCM ON SCHEDULING	2007
2	Gang Niu	RCM ON OPTIMIZATION FUSION DATA	2010

K. Naresh Raj: "Reliability Centered Maintenance on high Productivity Machines by Managerial Approach" International Journal of Engineering and Technical Research (IJETR) (2014) This paper explores the application of Reliability-Centered Maintenance (RCM) on high-productivity machines using a managerial approach. It discusses the implementation process, challenges, and benefits of RCM in enhancing machine reliability and productivity. The study emphasizes the role of management in successfully adopting RCM practices in industrial settings (2014) [8]
K. Naresh Raj: "Critical Analysis of Reliability Centered Maintenance on High Productivity Machines with managerial approach" International Journal of Engineering and Technical Research (IJETR) (2015) This paper provides a critical analysis of Reliability-Centered Maintenance (RCM) on high-productivity machines from a managerial perspective. It examines the effectiveness of RCM in improving machine performance and reducing downtime. The study highlights the importance of management support and involvement in the successful implementation of RCM strategies (2015) [9].
Y. T. Chang and H. H. Lin: "A Reliability-Centered Maintenance Approach for Machine Tool Maintenance" (2017) This paper presents a Reliability-Centered Maintenance (RCM) approach for the maintenance of machine tools. It discusses the process of identifying critical components and determining suitable maintenance tasks to ensure optimal performance and reliability. The proposed RCM framework aims to enhance the efficiency and effectiveness of machine tool maintenance. (2017) [10].L. F. Silva and P. A. R. F. Martins: "Reliability-Centered Maintenance Applied to Industrial Machines: A Case Study" (2018)This case study investigates the application of Reliability-Centered Maintenance (RCM) to industrial machines. It details the implementation process, challenges encountered, and benefits realized. The study demonstrates how RCM can be effectively used to improve the reliability and operational efficiency of industrial machinery (2018) [11].
J. R. Urbina and M. A. Silva: "Reliability-Centered Maintenance: A Framework for Optimal Maintenance Strategies" (2019) This paper presents a framework for developing optimal maintenance strategies using Reliability-Centered Maintenance (RCM). It discusses the principles of RCM and outlines a structured approach for identifying and implementing maintenance tasks. The proposed framework aims to enhance system reliability and reduce maintenance costs (2019)[12]

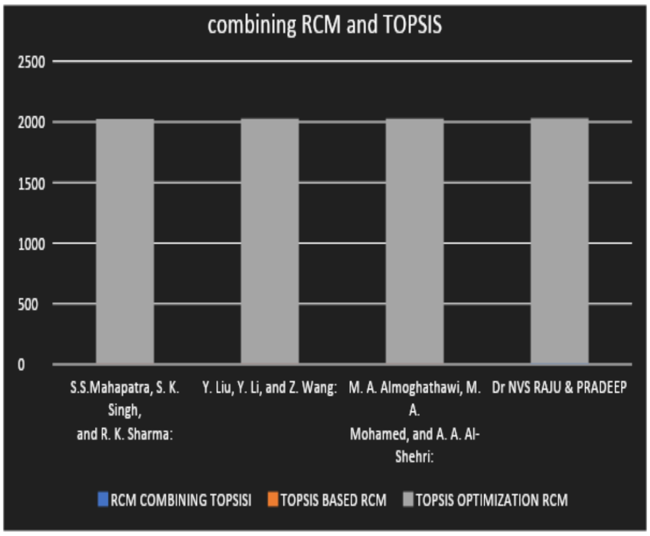
M. F. Al-Mamun and M. A. Karim: "RCM Analysis for Maintenance Optimization of Manufacturing Machines" (2020)This paper explores the use of Reliability-Centered Maintenance (RCM) analysis for optimizing the maintenance of manufacturing machines. It discusses the process of identifying critical components and determining appropriate maintenance tasks. The study highlights the benefits of RCM in improving machine reliability and reducing maintenance costs in a manufacturing environment (2020)[13].



17.A. K. Singh, P. K. Singh, and R. K. Sharma: "Integrating TOPSIS with RCM for Maintenance Decision-Making" (2017) This paper presents a methodology for integrating the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) with Reliability-Centered Maintenance (RCM) for maintenance decision-making. It discusses the benefits of combining these two approaches to enhance the prioritization and selection of maintenance tasks. The study highlights the improved decision-making capabilities achieved through this integration (2017)[14]S. S. Mahapatra, S. K. Singh, and R. K. Sharma: "A Hybrid Approach: Combining RCM and TOPSIS for Maintenance Optimization" (2018) This paper presents a hybrid approach that combines Reliability-Centered Maintenance (RCM) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for maintenance optimization. It discusses the integration of these two methodologies to enhance (2018) [15]S. S. Rao, K. V. S. Raju, and P. R. Kumar: "Evaluating Maintenance Alternatives using RCM and TOPSIS" (2019) This paper evaluates maintenance alternatives using a combination of Reliability-Centered Maintenance (RCM) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). It discusses the process of integrating RCM principles with TOPSIS to prioritize and select the best maintenance strategies. The study highlights the benefits of this approach in improving maintenance decision-making(2019)[16].

Y. Liu, Y. Li, and Z. Wang: "A TOPSIS-based Approach to Prioritize Maintenance Tasks in RCM" (2018) This paper proposes a TOPSIS-based approach for prioritizing maintenance tasks in Reliability-Centered Maintenance (RCM). It discusses the integration of TOPSIS with RCM principles to rank maintenance tasks based on their criticality and impact on system reliability. The study demonstrates the effectiveness of the proposed method in optimizing maintenance planning (2018)[17].
M. K. Singh, P. K. Singh, and A. K. Singh: "A Case Study on Applying TOPSIS to Optimize RCM in the Manufacturing Industry" (2019)This case study investigates the application of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to optimize Reliability-Centered Maintenance (RCM) in the manufacturing industry. It details the implementation process, challenges faced, and outcomes achieved. The study demonstrates the effectiveness of TOPSIS in enhancing RCM practices and improving maintenance efficiency (2019)[18].M. A. Almoghathawi, M. A. Mohamed, and A. A. Al-Shehri: "Optimizing Reliability Centered Maintenance Strategies using TOPSIS" (2020) This paper presents a method for optimizing Reliability-Centered Maintenance (RCM) strategies using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). The proposed approach integrates RCM principles with TOPSIS to prioritize maintenance tasks and enhance decision-making. The study

demonstrates the effectiveness of the method in improving maintenance planning and execution (2020) [19]. J. Liu, Y. Li, and Z. Wang: "Using TOPSIS to Evaluate the Effectiveness of RCM Strategies" (2020) This paper explores the use of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the effectiveness of Reliability-Centered Maintenance (RCM) strategies. It discusses the process of integrating TOPSIS with RCM principles to assess and compare different maintenance strategies. The study highlights the benefits of this approach in optimizing maintenance planning and execution (2020) [20].Pradeep,N V S Raju published research paper on "Reliability analysis of dumpers through FMEA-TOPSIS Integration"(2021)[21]



INDUSTRY PROFILE AND DATA COLLECTED OF AUTOMATED MACHINES BREAK DOWN OF 2023-20

Table 1.1: MACHINES BREAK DOWN REPORT FOR ONE YEAR IN mins (2023-2024)

M/C No.	Air Lift Unit	Feeder	Chamber	Pre-Suction unit	Post Suction Unit	Lower Screen Section	Screen Section	Upper Screen Section	Cross Flow Unit	Blow Head	Spool Valve
25	766	161	741	151	561	821	386	316	171	401	361
26	576	96	376	121	351	101	106	561	551	166	21
27	226	111	166	176	186	946	121	391	1	1	641
28	2021	326	1676	441	776	1676	491	491	391	301	86
29	596	261	181	766	261	4421	591	591	431	101	386
11	586	21	366	901	736	231	801	811	671	306	701
12	536	301	406	431	1006	351	646	1101	551	351	421
13	511	136	3361	401	141	381	46	801	191	1	1931
14	486	166	236	616	481	261	251	641	311	51	546
15	751	81	336	406	236	476	281	851	421	21	236
16	1226	41	151	661	336	296	321	381	236	236	1
17	1506	206	1031	1391	531	506	146	1081	901	136	226
Total	**9787**	**1907**	**9027**	**6462**	**5602**	**10467**	**4187**	**8017**	**4827**	**2027**	**5557**
VN	**3297.33**	**640.02**	**4050.82**	**2219.03**	**1843.45**	**4989.33**	**1446.57**	**2473.48**	**1613.46**	**763.69**	**2345.27**

Normalization of Decision Matrix:

Let X be the decision matrix with 'm' alternatives and 'n' criteria.
Normalize each element 'x_{ij}' of the matrix by dividing it by the square root of the sum of the squares of all elements in the corresponding column:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad i = 1,\dots,m;\ j = 1,\dots,k-1$$

Table 1.2: Normalised Decision Matrix

M/C	Air Lift Unit	Feeder	Chamber Unit	Pre Suction Unit	Post Suction Unit	Lower Screen Section	Screen Section	Upper Screen Section	Cross Flow Unit	Blow Head	Spool Valve
25	0.2323091714	0.2515546389	0.1829259261	0.06804775059	0.304320703	0.1645511522	0.2668381067	0.1277552275	0.1059834145	0.5250821668	0.15392684
26	0.174686792	0.1499953126	0.09282071284	0.05452832995	0.1904038623	0.02024319899	0.07327678578	0.2268059576	0.3415021135	0.217365685	0.008954192907
27	0.06854030382	0.1734320802	0.04097935727	0.07931393447	0.1008977732	0.1896046163	0.08364614225	0.1580768795	0.0006197860499	0.001309431838	0.2733160787
28	0.6129201505	0.5093590825	0.4137433902	0.1987354835	0.4209498495	0.3359168466	0.339423602	0.198505749	0.2423363455	0.3941389831	0.03666955191
29	0.1807523057	0.4077997563	0.04468231124	0.3451958739	0.1415823592	0.886090918	0.4085526452	0.2389346184	0.2671277875	0.1322526156	0.1645865934
11	0.1777195488	0.03281147464	0.09035207686	0.4060332668	0.3992514036	0.04629880164	0.5537236359	0.3278781312	0.4158764395	0.4006861423	0.2988994871
12	0.1625557648	0.4702978032	0.1002266208	0.19422901	0.5457159131	0.07035012717	0.446573619	0.4451218526	0.3415021135	0.459610575	0.1795102483
13	0.1549738728	0.2124933596	0.8297085528	0.1807095893	0.07648702162	0.07636295855	0.03179935987	0.3238352443	0.1183791355	0.001309431838	0.8233593573
14	0.1473919808	0.2593668948	0.05825980913	0.2775987706	0.2609238113	0.05231163302	0.1735138984	0.2591490532	0.1927534615	0.06678102371	0.2328090156
	0.2277600	0.1265585	0.0829461	0.182962	0.1280208	0.0954035	0.1942526	0.3440496	0.2609299	0.0274980	0.1006280

15	362	45	6892	8261	305	9126	113	79	27	6859	727
16	0.3718159844	0.06406049811	0.0372764033	0.2978779016	0.1822669451	0.05932660297	0.2219042286	0.1540339926	0.1462695078	0.3090259137	0.0004263901384
17	0.456733175	0.3218649417	0.2545163695	0.6268504707	0.2880468686	0.1014164226	0.100928403	0.4370360787	0.5584272309	0.1780827299	0.09636417129

Weighted Normalized Decision Matrix:

Multiply each normalized element '*r*ij' by the weight '*wj*' assigned to the corresponding criterion:

$$v_{ij} = w_j \cdot r_{ij}$$

Table 1.3: Weighted Normalised Decision Matrix

M/C	Air Lift Unit	Feeder	Chamber Unit	Pre Suction Unit	Post Suction Unit	Lower Screen Section	Screen Section	Upper Screen Section	Cross Flow Unit	Blow Head	Spool Valve
25	0.05807729284	0.06288865973	0.04573148153	0.01701193765	0.07608017576	0.04113778804	0.06670952667	0.03193880686	0.02649585363	0.1312705417	0.03848171
26	0.04367169801	0.03749882816	0.02320517821	0.01363208249	0.04760096558	0.005060799747	0.01831919644	0.0567014894	0.08537552837	0.05434142126	0.002238548227
27	0.01713507596	0.04335802006	0.01024483932	0.01982848362	0.0252244433	0.04740115406	0.02091153556	0.03951921988	0.0001549465125	0.0003273579594	0.06832901969
28	0.1532300376	0.1273397706	0.1034358476	0.04968387088	0.1052374624	0.08397921164	0.08485590051	0.04962643725	0.06058408637	0.09853474577	0.009167387977
29	0.04518807641	0.1019499391	0.01117057781	0.08629896847	0.03539558979	0.2215227295	0.1021381613	0.05973365461	0.06678194687	0.0330631539	0.04114664836
11	0.04442988721	0.00820286866	0.02258801922	0.1015083167	0.0998128509	0.01157470041	0.138430909	0.0819695328	0.1039691099	0.1001715356	0.07472487176
12	0.0406389412	0.1175744508	0.0250566552	0.04855725249	0.1364289783	0.01758753179	0.1116434047	0.1112804632	0.08537552837	0.1149026437	0.04487756207
13	0.0387434682	0.0531233399	0.2074271382	0.04517739733	0.0191217554	0.01909073964	0.007949839966	0.08095881107	0.02959478388	0.0003273579594	0.2058398393
14	0.0368479952	0.0648417237	0.01456495228	0.06939969266	0.06523095283	0.01307790826	0.0433784746	0.06478726329	0.04818836538	0.01669525593	0.0582022539
15	0.05694000904	0.03163963626	0.02073654223	0.04574070652	0.03200520763	0.02385089782	0.04856315284	0.08601241975	0.06523248175	0.006874517147	0.02515701817
16	0.09295399611	0.01601512453	0.009319100824	0.0744694754	0.04556673628	0.01483165074	0.05547605716	0.03850849815	0.03656737694	0.07725647841	0.0001065975346
17	0.1141832938	0.08046623543	0.06362909238	0.1567126177	0.07201171716	0.02535410566	0.02523210076	0.1092590197	0.1396068077	0.04452068248	0.02409104282
V+	0.01713507596	0.00820286866	0.009319100824	0.01363208249	0.0191217554	0.005060799747	0.007949839966	0.03193880686	0.0001549465125	0.0003273579594	0.0001065975346
V-	0.1532300376	0.1273397706	0.2074271382	0.1567126177	0.1364289783	0.2215227295	0.138430909	0.1112804632	0.1396068077	0.1312705417	0.2058398393

Ideal and Negative Ideal Solutions:

Determine the ideal solution (positive ideal solution) +A+ and negative ideal solution −A− by taking the maximum and minimum values, respectively for each criterion across all alternatives.
Similarity Scores:
Calculate the similarity of each alternative to the ideal and negative ideal solutions using a chosen distance metric (commonly Euclidean distance or Manhattan distance):

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}$$

Relative Closeness to Ideal Solution:

Calculate the relative closeness of each alternative to the ideal solution:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

Ranking:

Rank the alternatives based on their relative closeness 'C*i*', where a lower value indicates a higher rank. This is a simplified explanation, and the actual implementation might involve additional considerations, such as normalization methods, distance metrics, and other variations. The weights assigned to criteria are often based on the decision-maker's preferences or can be determined through various methods, including analytic hierarchy process (AHP) or expert opinions.

Table 1.4: Ranking of Machinery

M/C	Si+(plus)	Si- (Minus)	Si(+) + Si-	Pi	Rank
25	0.1825245389	0.3837868516	0.5663113905	0.6776958014	6
26	0.1160674801	0.4437889955	0.5598564756	0.7926835088	2
27	0.08935800216	0.4475939158	0.536951918	0.8335828606	1
28	0.2759040204	0.3079419548	0.5838459753	0.5274369746	12
29	0.2807473273	0.334733341	0.6154806682	0.5438567907	11
11	0.247061323	0.359096733	0.606158056	0.5924143537	7
12	0.2595030888	0.3593794962	0.6188825849	0.5806909176	8
13	0.2975220052	0.3646759223	0.6621979275	0.5507053212	10
14	0.1311825768	0.4065302263	0.5377128031	0.7560359805	4
15	0.1152950947	0.4218338378	0.5371289325	0.7853493124	3
16	0.1408949671	0.425502447	0.5663974141	0.7512436259	5
17	0.2636728063	0.3469979633	0.6106707696	0.568224288	9

a) **Evaluated Parameters :**

Time of failure per shift is f(t):18.46~18.5mins. Time of maintenance per shift is m(t) : 291.14mins.

Time of expected probability : 3.0 mins of hazard failures in shift

Total time of failure per shift is : 18.5 + 3 = 21.5 minutes Total time of maintenance per shift m(t):291.14+33 = 324.14 mins

Total operating time per shift : 8x60 = 480 minutes Number of runs per shift is : 98.7 / 480 *100 =20.56 mins. Total number of runs per shift is : 20.56 + 3.0= 23.56 mins Average breakdown time i.e., for a month is : 194 mins Average breakdown time for shift is : 194/30 = 6.466 mins Down time per shift : 6.466 / 480*100 = 1.347 mins.

Uptime per shift : (1 – 0.013)*100 = 98.7 mins.

Percentage of break down time per month = 44.9 mins

b) **Calculations for Machine no. 15 (mins/ shift-day):-**

MTD (Mean Down Time) : (1.347+23.56)/44.9= 0.55mins. MTBF (Mean Time Between Failures) : 480 / 18.5 = 25.94 mins.

MTTF (Mean Time To Failure) : 480 / 21.5= 22.32 mins. MTBM (Mean Time Between Maintenance): 480/23.56 = 20.37m

Calculations for Machine no. 15 (mins / shift-year)

MDT = 0.55x11x30 = 181.5 min MTBF = 25.94 x 11x30 = 8560.2 min MTTF = 22.32x11x30 = 7365.6 min MTBM = 20.37x11x30 = 6722.1 min

Final Calculations

Reliability: **Ro = 1 – F(t)**

= 1- 21.5/100 = 0.785*100 = **78.5%.**

Maintainability: **Mo = M(t)/Total operating Time**

= 324.0/432 = 0.75*100 = **75%.**

Operational Availability: **Ao = MTBM/(MTBM+MDT)**

= 6250.2/(6250.2+178.2)
= 0.9722*100=**97.22%**

Table 2.1: Maintenance Analysis of Machine No. 15 for one shift- day(480 mins)

Components	**Quantity (ni)**	**Failure Rate (BreakTime/11x30) 'λ' per shift**	**ni x λ (in minutes)**	**Maintenance time in minutes (tmi per shift)**	**ni x λ x tmi time in minutes per shift**
Air Lift Unit	2	1.62	3.24	32.4	104.97
Feeder	1	0.92	0.92	9.2	8.46
Chamber	2	1.227	2.45	24.5	60.02
Pre-Suction Unit	2	1.303	2.6	26	67.6
After Suction Unit	1	3.045	3.045	30.45	92.72
Lower Screen Section	1	1.06	1.06	10.6	11.23
Screen Section	1	1.954	1.954	19.54	38.18
Upper Screen Section	2	3.333	6.666	66.66	444.35
Cross Flow Unit	1	1.667	1.667	16.67	27.78
Blow Head	4	1.06	4.24	42.5	179.77
Spool Valve	1	1.272	1.272	12.72	16.17
Total		f(t) = 18.46 minutes		m(t) = 291.14 mins	

Table 2.2: Summary of Performance of Various Machines studied (min/shift-year)

Machine No.	**MTBF**	**MTTF**	**MTBM**	**Ao**	**Ro**	**Mo**	**Average**	**Rank**
17	11404.8	9187.2	6230.4	97.57	84.5	50.81	77.626	4
14	11404.8	9197.1	6804.6	97.72	84.5	53.47	78.563	3
27	5940	5280	6230.4	95.93	73	97.7	88.876	9
29	15840	11880	6233.7	98.18	88	35.03	73.736	1
15	8560.2	7365.6	6722.1	97.22	78.5	75	83.573	11

CONCLUSION/RESEARCH GAP

From [14],[15],[16],[17],[18],[19],[20] research is on evaluation, optimization of reliability centered maintenance of systems. From [21] comparison taken place on FMECA and TOPSIS. this research is comparison of Reliability Centered Maintenance and TOPSIS on High Productivity machines. Which is new Progress and new era of in the direction of maintenance of machines

REFERRENCES

[1] J Moubray: “Reliability Centered Maintenance” (1997)
[2] M. Rausand: “Reliability Centered Maintenance” Reliab Eng Syst Saf (1998)
[3] V. S. Deshpande et al.: “Modelling of uncertainties in reliability centered maintenance: probabilistic approach” (2001)
[4] V. S. Deshpande et al.: “Application of RCM to a medium scale industry” Reliab Eng Syst Saf (2002)
[5] V. S. Deshpande et al.: “Application of RCM for safety considerations in a steel plant” Reliab Eng Syst Saf (2002)
[6] Xiaojun Zhou et al.: “Reliability centered predictive maintenance scheduling for a continuously monitored system subject to degradation” Reliab Eng Syst Saf (2007)
[7]Gang Niu et al.: “Development of an optimized condition-based maintenance system by data fusion and reliability-

Shehri: “Optimizing Reliability Centered Maintenance Strategies using TOPSIS” (2020)

centered maintenance” Reliab Eng Syst Saf (2010)
[8] K. Naresh Raj: “Reliability Centered Maintenance on high Productivity Machines by Managerial Approach” International Journal of Engineering and Technical Research (IJETR) (2014).
[9] K. Naresh Raj: “Critical Analysis of Reliability Centered

Maintenance on High Productivity Machines with managerial approach” International Journal of Engineering and Technical

Research (IJETR) (2015)
[10] Y. T. Chang and H. H. Lin: “A Reliability-Centered Maintenance Approach for Machine Tool Maintenance” (2017)

[11]L. F. Silva and P. A. R. F. Martins: “Reliability-Centered Maintenance Applied to Industrial Machines: A Case Study” (2018)
[12]J. R. Urbina and M. A. Silva: “Reliability-Centered Maintenance: A Framework for Optimal Maintenance Strategies” (2019)
[13] M. F. Al-Mamun and M. A. Karim: “RCM Analysis for Maintenance Optimization of Manufacturing Machines” (2020)
[14] M. A. Almoghathawi, M. A. Mohamed, and A. A. Al-
[15] S. S. Rao, K. V. S. Raju, and P. R. Kumar: “Evaluating Maintenance Alternatives using RCM and TOPSIS” (2019)
[16] Y. Liu, Y. Li, and Z. Wang: “A TOPSIS-based Approach to Prioritize Maintenance Tasks in RCM” (2018)
[17] A. K. Singh, P. K. Singh, and R. K. Sharma: “Integrating TOPSIS with RCM for Maintenance Decision-Making” (2017)
[18] M. K. Singh, P. K. Singh, and A. K. Singh: “A Case Study on Applying TOPSIS to Optimize RCM in the Manufacturing

Industry” (2019)
[19] J. Liu, Y. Li, and Z. Wang: “Using TOPSIS to Evaluate the Effectiveness of RCM Strategies” (2020)
[20] S. S. Mahapatra, S. K. Singh, and R. K. Sharma: “A Hybrid Approach: Combining RCM and TOPSIS for Maintenance Optimization” (2018)

[21] Pradeep and Dr.NV S Raju published research paper on “Reliability analysis of dumpers through FMEA-TOPSIS Integration”(2021)

Acknowledgments

The Author would like to thank the management of JNTUH KUKATPALLY HYDERABAD, for supporting this work.

Biography:

*Dr. **NVS RAJU**, Principal of University College of Engineering Wanaparthy, Professor in JNTUH University*

College of Engineering, Science & Technology Hyderabad.

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.

Mr. K REVANTH ,M.TECH-2024 PASSING, JNTUH Kukatpally, Hyderabad