Comparison of Reliability Centered Maintenance and TOPSIS Mathematical Technique on High Productivity Machines

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Abstract-: Reliability Centered Maintenance on High Productivity Machines in terms of machine wise and component wise using Reliability Engineering Assessment, Machine wise, Component wise repair and replacement time Analysis, Cost Analysis, Failure Mode and Heat Analysis. Sorting of machines is done with the help of above analyzed data. Addition to this, applying TOPSIS Mathematical Technique for Assessment and comparing results, give more efficient and effective ranking of unreliable machines. The Conclusion of this paper is to generate the right time for a Remedial Action Plan. This work also recommends an action plan for the Maintenance Program.

Key Words— Reliability Assessment, FMEA on Repairs and Replacements, Cost Analysis, TOPSIS Mathematical Technique

I. INTRODUCTION

Till now Reliability Centered Maintenance (RCM) has been applied on machines but in this paper RCM is on high productivity machines i.e Automated Machines. This RCM will perform Reliability Assessment, Failure Mode Effective Analysis for generating efficient and effective results of machinery whether they are reliable or unreliable. In addition to this, RCM for Machine wise, Component wise and Time, Cost Analysis is calculated. Reliability Centered Maintenance Analysis results in classification of machines and their components are reliable or not. In this paper we are comparing the Reliability Centered Maintenance with TOPSIS mathematical technique for generating data for reliable and unreliable machines and their components. RCM data enables the segregation of reliable and unreliable machines, but the ranking of machines and their components are given by the TOPSIS technique. Comparison of both results gives an effective and efficient way for remedial action.

The TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method involves several mathematical steps. Here's an overview of the mathematical calculations involved in the TOPSIS algorithm:

COLLECTED DATA FOR ANALYSIS FROM MANUFACTURING INDUSTRY MACHINE PHOTOS

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

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:

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

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
15	0.2277600362	0.126558545	0.08294616892	0.1829628261	0.1280208305	0.09540359126	0.1942526113	0.344049679	0.260929927	0.02749806859	0.1006280727
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 '*w*j' 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

II. MAINTENANCE ANALYSIS PROCESS

Data Extrusion: Out of all the data collected, extract the required data from each machine throughout the shift-year in minutes.

Maintenance Analysis: Analyse each machine's sub element data for failure rate, maintenance rate and total time rate in both the functions.

Evaluated Parameters: Evaluate the parameters and list them accordingly.Ex: **MTBM, MTTF, MTD,** etc.

Final Calculations: The Reliability, Availability and Maintainability is calculated and determined for one Shift-year.

Summary of Performance of Machines: Reliability, Availability, Maintainability of machines are sequentially arranged.

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	

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 2.2: 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

The evaluated parameters are calculated for five machines and tabled. FMEA analysis is also conducted for reliability study. It is a Qualitative Analysis. FMECA is also used to indicate criticality analysis. Quality Engineering is part of FMEA.

Table 2.3: FME Analysis for CIMBRIA DELTA CLEANER

Machine Name: Delta Cleaner				Suppliers : CIMBRIA					Prepared by: Self				
Responsibility: Manufacturing				Model Date: 2021					FMEA Date: 18/12/23				
Other Areas Involved				Engineering Level Change									
Process Operation Function	Potential Failure Mode	Failure Potential Effects	SEV	Failure Cause	OCC	DET	RPN	Completion Date	Action Results				
									Actions Taken	SEV	OCC	DET	RPN
Air Lift Unit	Broken Head Bolts	Damage to Header Unit and Leakage	9	Due to heavy Vibration	7	8	504	18-12-2023	Head Bolts Replaced	7	5	7	245
Feeder	Links	Broken Link Pins	6	Due to Overload	7	7	294	18-12-2023	Link pins Replaced	5	5	5	125
Chamber	Broken Damper Plate	Leakage and damage of product	8	Due to Damping	8	9	576	18-12-2023	Damper Plate Replaced	6	6	7	252
Pre Suction Unit	Clogged Filter	Damage to the Chamber	8	Dust Settled at Filter	8	8	512	18-12-2023	Filter Replaced	7	6	6	252

After Suction Unit	Lock Ring Loose	Damage to the Suction Unit	7	Due to Vibration	9	6	378	18-12-2023	New Ring Replaced	5	8	4	160
Lower Screen Section	Broken Finger Plate	Damage to Product and Screens	6	Due to Vibrations	7	7	294	18-12-2023	Welded and Repaired	4	5	5	100
Screen Section	NP	NP	NP	NP	NP	NP	NP	18-12-2023	NP	NP	NP	NP	NP
Upper Screen Section	Broken Lock	Product Damage	7	Due to Vibrations	8	7	392	18-12-2023	Replaced with new Lock	5	6	5	150
Cross Flow Unit	Setting Required	Damage to Product Quality	5	Due to Wear and Tear	8	7	280	18-12-2023	Plasted the surface	3	5	5	75
Blow Head	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Spool Valve	Loose Plunger	Leakage and Damage to Product	8	Due to Fluctuations in Load	7	6	336	18-12-2023	Tighten the Plunger Tool	5	5	5	125

III. DESIGN OF SEED INLET CHAMBER

The seeds flowing through the underground sump to the chemical mixer have to pass through the filter chamber. Here the design of the chamber pathway is perpendicular to the inlet of the chemical mixer. This causes resistance to the seeds flowing through the chamber. The design of the inlet chamber has been modified according to the circumstances.

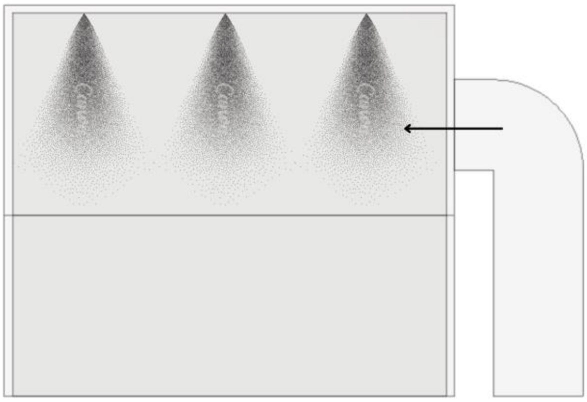


Fig 3.1: Chemical Mixing chamber inlet at 90° angle.

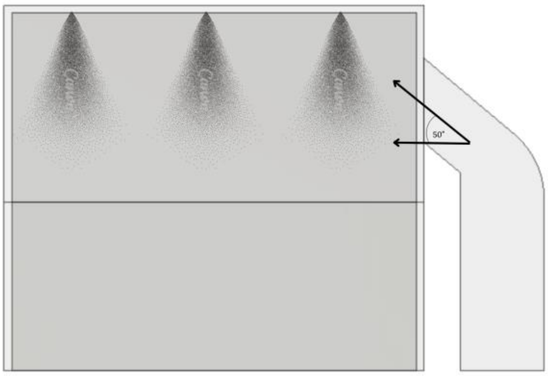


Fig 3.2: Chemical Mixing Chamber inlet at 50° angle.

In modified design, the angle of the inlet chamber has been adjusted to 30°. By this modification the resistance to the flow of seeds has been reduced and the uniformity in mixing of the chemical has been increased.

IV. REPAIR AND REPLACEMENT COST ANALYSIS AND FAILURE TIME ANALYSIS

In cost analysis we consider the number of repairs, quantity of items repaired and the cost incurred by them. On this basis the cost of parts for repair or replacement is calculated. This also includes the replaceable parts for every month or three months in duration. An additional cost may also appear for repair shop maintenance. This information is to know the investment status for maintenance of repair.
The determination comes out by dividing the product of component's repair time with quantities for a period of three months and performing the same calculation with one month duration time. This analysis states the time consumption for repairs and replacement for strategy.

Table 4.1: Repair Cost Analysis for Components of Machine No. 15

Component	Quantity	Repair Time per month (min)	No. of repairs in a month	Repairing Cost in a month (Rs)
Air Lift Unit	2	536/11= 48.72	3x2 =6	3000x6 =18000
Feeder	1	301/11 =27.36	2x1=2	3500x2 =7000
Chamber	2	406/11 =36.90	2x1=2	4000x2 =8000
Pre-Suction Unit	2	431/11 =39.18	2x1=2	3500x2 =7000
After Suction Unit	1	1006/11 =91.45	4x1=4	5500x4 =22000
Lower Screen Section	1	351/11 =31.90	2x1=2	6500x2 =13000
Screen Section	1	646/11 =58.72	3x1=3	6500x3 =19500
Upper Screen Section	2	1101/11 =100.09	4x2=8	4500x8 =36000
Cross Flow Unit	1	551/11 =50.09	3x1=3	3500x2 =7000
Blow Head	4	351/11 =31.90	2x4=8	5500x8 =44000
Spool Valve	1	421/11 =38.27	2x1=2	3000x2 =6000
Total			42	187500

Table 4.2: Replacement Cost Analysis for Components of Machine No. 15

Component	Quantity	No. of Failures / Month	Components Cost	Replacement
Air Lift Unit	2	6	4500	27000
Feeder	1	2	5000	10000
Chamber	2	2	5500	11000
Pre-Suction Unit	2	2	4750	10500

After Suction Unit	1	4	8000	36000
Lower Screen Section	1	2	7250	14500
Screen Section	1	3	7500	22500
Upper Screen Section	2	8	5250	42000
Cross Flow Unit	1	3	4250	12750
Blow Head	4	8	6100	48800
Spool Valve	1	2	3750	7500
Total				2,37,500

Table 4.3: Summary of Replacement and Repair of Machines.

Machine No.	**Repair Time**	**Replacem ent Time**	**Time Saved**	**Productivity Increment**
29	553.54	210	353.54	176.7
17	777.23	175	604.05	302.005
14	269.09	95	173.59	87.13
15	371.328	150	281.42	123.51
27	366.77	160	281.42	123.51
Total	2337.958	790	1694.02	812.855

Table 4.4: Summary of Replacement and Repair Cost

S.No.	**Machine No.**	**Replacement Cost (Rs)**	**Repair Cost**
1	29	237550	187500
2	17	202000	185500
3	14	173800	189000
4	15	158650	151000
5	27	95000	92000
TOTA L		867000	805000

V. RESULTS

Total Replacement Cost = Rs 8,67,000

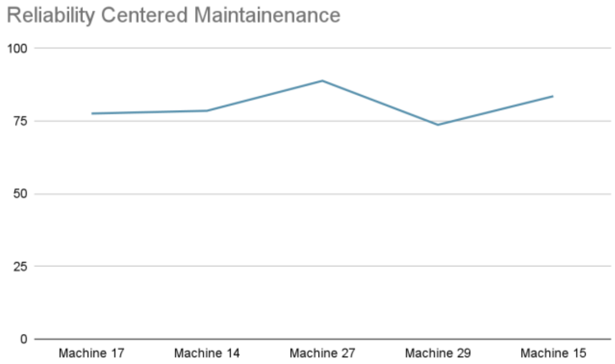
Total Repair Cost of Machine = Rs 8,05,000

Cost saved by Repair = Total Cost for Replacement - Total Cost of Repair = Rs 62000

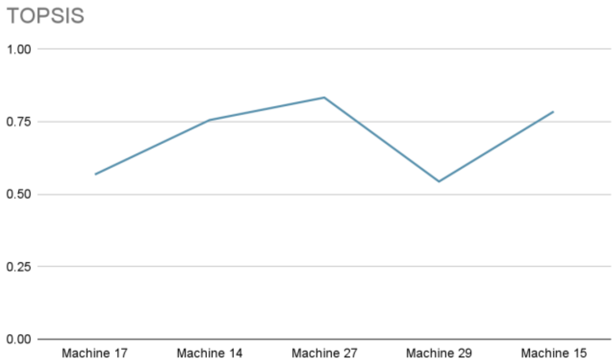
Time saved by Replacement = Total time taken for repair - Total time taken for replacement= 1547.95 minutes

Increase in productivity by replacement = 818.193

A. Graphical Representation:



Graph 5.1: RCM vs Performance of Machines.



Graph 5.2: TOPSIS vs Performance of Machines.

TOPSIS and RCM indicated that Machine No. 29 is the Worst and Machine No. 27 is Best of the 5 machines considered.

A. SUMMARY OF ANALYSIS

SEED Inlet Chamber

Efficiency of the Chamber has been increased by 50%.

Easier handling.

The design is rigid.

Chronic problems in Machine 29

Maintainability is very low when compared with other machines i.e 35%

Chamber Unit has high RPN of 252

The Pre Suction Unit has a high RPN of 252. Air Lift Unit has a high RPN of 245.

Chronic problems in machine 27

Maintainability is highest of all machines i.e 97.7%

Air Lift Unit has high RPN of 245

Chronic problems in machine 14
Maintainability is low i.e 53.47%
Air Lift Unit has a high RPN of 245
Screen Section has a high RPN of 216

Chronic problems in machine 17
Machine Maintainability is low i.e 50.81%
Air Lift Unit has high RPN of 210
Blow head component has high RPN of 210

Chronic problems in machine 15
Maintainability is moderate i.e 75%
Air Lift Unit has a high RPN of 210.

VI. DISCUSSIONS

Identification of Chronic Problems has been achieved by FMEA, Designing and TOPSIS techniques. The advancement of the machine part is recommended. This analysis is done by evaluating the Availability, Reliability, Maintainability and Risk Priority Number of Machines.
Total Replacement Cost of Machines is Rs 8,67,000.
Total Repair Cost of Machine = Rs 8,05,000.
Cost saved by Repair = Total Cost for Replacement - Total Cost of Repair = Rs 62000.
Time saved by Replacement = Total time taken for repair - Total time taken for replacement= 1547.95 minutes
Increase in productivity by replacement = 818.193 minutes.
Preparation of Operation Sheets of Components has been issued for failure reduction. By forwarding this data to the Design Engineering department, it will help for the upgradation of the Machine.

A. MAINTENANCE PLAN

Recommended Maintenance Plan for Optimising Productivity:

Maintenance Task for Machine No.29

1. Periodical replacement of variables (Air Lift Unit arm, Feeder Unit, Pre Suction Unit, cartridges) must be done for every 30 - 35 days.
2. RPN of Chamber Unit(252), Pre Suction (252), Air Lift Unit(245) should reduce.
3. Chamber,ba,Air Lift Unit should be remodeled for increasing Operational Efficiency.

Maintenance Task for Machine No.27

1. Periodical changing of variables (Air Lift Unit arm, Feeder Unit, Pre Suction Unit, cartridges) must be done for every 30 - 35 days.
2. RPN of Blow Head (210),Air Lift Unit (245) should be reduced.
3. Blow Head, Air Lift Unit should be remodeled for increasing Operational Efficiency.

Maintenance Task for Machine No.14

1. Periodic changing of variables (Air Lift Unit,Feeder Unit, Pre Suction Unit, Upper Screen Section, Cartridges) should be changed once in a month.
2. RPN of Air Lift Unit (245), Screen Section (216) should be reduced.

Maintenance Task for Machine No. 17

1. Periodic changing of variables (Air Lift Unit,Feeder Unit, Pre Suction Unit, Upper Screen Section, Cartridges) should be changed once in a month.
2. Periodical changing of the blow head must be once in every 30 days.
3. RPN of Air Lift Unit arm 210 must be reduced.

Maintenance Task for Machine No. 15

1. Periodical replacement of variables (Air Lift Unit, Feeder Unit, Pre Suction Unit, Cartridges) must be done for every 30 - 35 days.
2. RPN of the Air Lift Unit (210) should be reduced.
3. The Air Lift Unit should be remodeled for increase in Operational Efficiency.

VII. CONCLUSIONS

This work is mainly focused on the 'Effective Maintenance Plan'. This is achieved by conducting FMEA, RCM, Cost analysis and Operational Analysis which is the conclusion of this paper. Incorporation of Artificial Intelligence for modeling, testing and analysing the components may have more scope which may increase the efficiency.

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