Selection of maintenance strategies based on AHP and TOPSIS techniques

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Abstract: The goal contests this study was on CNC machines production workshop Aviation Industry Corporation of Iran choosing the most important devices in terms of impact production as well as maintenance of its terms of complexity Specific interviewees., To select the MCDM method with techniques using AHP - we regard the CNC machines in our production play an important role Must try We do our best option Effect in produce plays most if not timely maintenance will result in production of a recession.

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1. Introduction

Maintenance has emerged since the construction of physical structures such as ships and machines. In general, maintenance is defined as the combination of all technical and administrative actions, including supervision and action intended to retain the machine or restore it to a state in which it can perform a required function [1] . Effective maintenance ultimately aims to determine suitable actions that can keep machine performance at acceptable levels and extend the life cycle of the machine. Different types of maintenance alternatives have been proposed to achieve the ultimate goal. However, a maintenance policy implemented in a similar machine but in different manufacturing environments may not produce similar results because of various operating factors such as humidity, temperature, and work load [2]. In addition, decision making in maintenance selection is often accompanied by diverse constraints and limitations from social, environmental, and economic perspectives [3]. Examples of these constraints include operator safety issues, government regulation, resource limitation, and budget. Consequently, the selection of a suitable maintenance policy becomes a crucial decision-making process to obtain high levels of success for the firm beneficiaries [4] .In manufacturing industries. The need to choose a suitable maintenance policy has led to the development of numerous multi-criteria decision-making (MCDM) approaches. This study examines the four most widely used MCDM methods in maintenance alternative decision making: analytic hierarchy process (AHP), elimination and choice expressing reality (ELECTRE), simple additive weighting (SAW), and technique for order preference by similarity to ideal solution (TOPSIS). The benefits and limitations of each alternative are identified to assist decision makers in choosing the suitable MCDM technique. (Comparison of Multi Criteria Decision Making Methods From The Maintenance Alternative Selection Perspective 1,Jureen Thor , 2, Siew-Hong Ding , Shahrul Kamaruddin).

Industry Forum was initially formed in 1994 as a unique collaboration between leading vehicle manufacturers, the SMMT and the government to improve the performance and competitiveness of the UK's automotive supply chain. By 1996 Industry Forum had developed a model to achieve this by seconding highly skilled master engineers from the founding partners to transfer their skills to Industry Forum engineers through a‘ learning by doing’ approach.

Continued measurable success has led to sustained growth into many other sectors including aerospace, construction, domestic appliances, electronics, and food. Industry Forum now provides support to blue chip organization s in more than 30 countries across five continents.

The constant pressure on businesses to reduce cost has driven the need to provide extremely reliable, efficient and sustainable processes that deliver proven returns over the long term. The Japan Institute of Plant Maintenance (JIPM) TPM excellence awards are the global benchmark for businesses achieving this level of sustained success.

Industry Forum Business Excellence through Inspired People Industry Forum is a Certified JIPM Associate Agency Industry Forum is one of only six worldwide agencies qualified to assess businesses against these criteria. Industry Forum has practical continuous improvement at its heart and its strategy is to align itself with world-leading partners to deliver complete solutions for customers.

Industry Forum delivers significant results in three ways:

1. Practical Solutions – providing knowledge, hands-on experience and guidance to improve business performance

2. Learning & Development – inspiring people through structured training and development program to deliver business excellence

3. Audit & Assessment – using globally recognized objective assessment criteria to understand, measure and monitor business performance.

Industry Forum employs a team of engineers all of whom have substantial industrial experience in key sectors. Consistent with its founding principles the team undergoes continuous training and development to meet the needs of our customer base. To support our customers on a global basis, Industry Forum has established a network of trained and validated partners and associates in major economic regions. The goal of Industry Forum is to grow its business in key sectors whilst retaining this unique approach.

Since Industry Forum was founded in 1994, with the aim of driving continuous improvement methods in automotive manufacture, it has successfully expanded to support aviation, petrochemical, electronics, food and beverage divisions on a global scale.

As an integral approach to business solutions TPM (Total Productive Maintenance) is a core support program affiliated with the Japanese Institute of Plan Maintenance (JIPM), considered being the global leading body, TPM is not just a professional maintenance approach but also a cultural transformation program.

Industry Forum teams are experienced practitioners and have a deep understanding from multiple environment soft application and hands on application. Our senior experienced teams have operated at corporate levels in large organizations and understand the holistic program approach and have worked directly with JIPM for awards activities. Our teams have core disciplines; although they have a wide range of knowledge our approach is to hone our expertise in core disciplines so that depth of application is assured.

The Japan Institute of Plant Maintenance (JIPM) TPM Excellence Awards are the global benchmark for businesses achieving this level of sustained success. Industry Forum is one of only six worldwide agencies qualified to assess/consult businesses against these criteria.

Industry Forum's TPM approach delivers significant results in three ways:

1. Program support material and knowledge, implementation approach and supporting materials to answer the 'why' and 'how' to implement.

2. Learning & Development – structured training and development program to support implementation. All our training materials are developed with training frameworks for effective delivery.

3. Audit & Assessment – experienced in applying the reflective process of audits and assessments exploring opportunities and creating competitive gaps in a constructive way.(Reference: Industry Forum Business Excellence Through Inspired People)

2. Literature review

A maintenance concept is a set of maintenance actions and policies and the general decision support structure in which these are planned and supported (Pintelon & Van Puyvelde, 2007). Besides equipment's, the selection of the appropriate maintenance strategy depends on the availability of maintenance facilities and capabilities.(Arunraj & Maiti, 2010) Therefore, an appropriate maintenance program must consider different maintenance strategies for different machines (Wang, Chu, & Wu, 2007).

Because of the importance of selecting the suitable maintenance strategy for equipment some studies have been done on this problem. For example: N.S. presents an approach of maintenance selection based on risk of equipment failure and cost of maintenance, using Analytic hierarchy process (AHP) and goal programming (GP). Wang et al, (2007) evaluated different maintenance strategies, AHP method is applied for this paper. Bertolini and Bevilacqua (2006), suggested an integration of AHP and lexicographic goal programming approach to determine the best maintenance strategy. Al-Najjar and Alsyouf (2003) assess the most popular maintenance approaches, using a fuzzy multiple criteria decision making (MCDM). Also Bevilacqua and Braglia (2000) employed AHP in an Italian oil refinery in order to selecting the optimum maintenance strategy.

Alternative maintenance strategies:

In current study three alternative maintenance strategies considered as follows:

-. Traditional maintenance: In this paper, three strategies for traditional maintenance defined as following:

Corrective maintenance, Predictive maintenance, Condition based maintenance (CBM)

-. Total productive maintenance (TPM) is a management initiative that has been widely embraced in the industry. A positive strategic outcome of such implementations is the reduced occurrence of unexpected machine breakdowns (Gosavi, 2006).TPM is a proven and successful procedure for introducing maintenance considerations into organizational activities (Eti, Ogaji, & Probert, 2004) and, provides a comprehensive company-wide approach to maintenance management (McKone, Schroeder, & Cua, 2001).

-. World-class maintenance: World industry in the world and, this must be supported by a combination of product design, quality, low manufacturing cost, innovation, shorter lead-time, reliable delivery performance and customer service. In simple terms, world-class manufacturers are those that demonstrate industry best practice .The goals of organizations should be therefore to maximize performance in these areas in order to achieve significant edge over their competitors (Kodali, Mishra, & Anand, 2009).

The JIPM definition of TPM is:

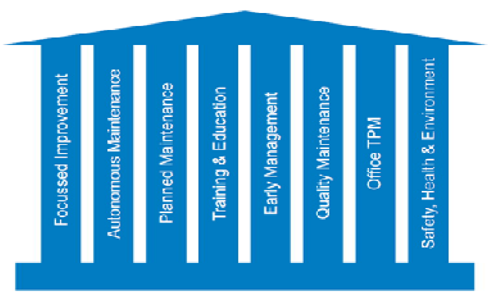
T = Total. Must involve all employees at all levels of the organization.

P = Productive. Effective utilization of all resources.

M = Maintenance. Keeping the Man-Machine-Material system in optimum condition.

JIPM developed an eight pillar approach to TPM focused on achieving:

• Zero Accidents
• Zero Break-downs
• Zero Defect



The mission of each pillar is to reduce loss with the ultimate aim of elimination of all losses.

To start implementation of TPM firstly top management need to understand that TPM needs to be part of a long-term culture change program, not just an initiative for the maintenance department.

A TPM structure to support the cultural change needs defined with clear responsibilities and ownership.

Next a pilot area needs to be identified. Typically this is selected based on reviewing data on breakdowns and quality issues. The operators involved in the area, along with other functions such as Maintenance and Quality are then trained in the principles of TPM and what role they will play in the implementation. In simple terms we build professional linked systems how we train, how we problem solve, how we maintain the power of TPM is greater than the key performance indicators measured at a single location. It is a mechanism or movement by which we transform our working environments and the way in which we work.

It can be said that pillars are themselves change streams; they develop systems, processes and standards with people. It allows and motivates a mechanism for leaders to work directly with the factory teams bridging gaps in hierarchies and forming a unified and cohesive structure that spans both levels and functions to achieve common aims. The pillar approach is a way of managing change and a rigorous methodology to ensure we sustain results for the future.

What is Focused Improvement?

Focused Improvement is the first pillar of TPM. It provides a structured, team-based approach to drive elimination of specifically identified losses in any process.

What is Autonomous Maintenance?

Autonomous Maintenance is the second of the eight pillars of TPM. It follows a structured approach to increase the skill levels of personnel so that they can understand, manage and improve their equipment and processes.

The goal is to change operators from being reactive to working in a more proactive way, to achieve optimal conditions that eliminate minor equipment stops as well as reducing defects and breakdowns.

What is Planned Maintenance?

Planned Maintenance is the third pillar of TPM and aims to achieve zero breakdowns. It follows a structured approach to establish a management system that extends the equipment reliability at optimum cost.

What is the Training and Education Pillar?

Training and Education is the fourth pillar of TPM. It ensures that staff are trained in the skills identified as essential both for their personal development and for the successful deployment of TPM in line with the organization's goals and objectives.

What is Early Management?

Early Management is the fifth pillar of TPM and aims to implement new products and processes with vertical ramp up and minimized development lead time. It is usually deployed after the first four pillars as it builds on the learning captured from other pillar teams, incorporating improvements into the next generation of product and equipment design.

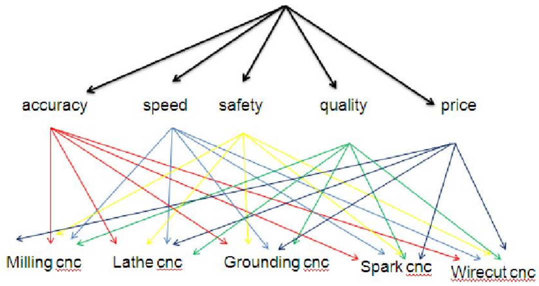
What is Quality Maintenance?

Quality Maintenance is the sixth pillar of TPM and aims to assure zero defect conditions. It does this by understanding and controlling the process interactions between manpower, material, machines and methods that could enable defects to occur. The key is to prevent defects from being produced in the first place, rather than installing rigorous inspection systems to detect the defect after it has been produced.

What is Office TPM?

Office TPM is the seventh pillar and concentrates on all areas that provide administrative and support functions in the organization. The pillar applies the key TPM principles in eliminating waste and losses from these departments. The pillar ensures that all processes support the optimization of manufacturing processes and that they are completed at optimal cost.

What is the Safety, Health and Environment Pillar?



Safety, Health and Environment (SHE) is the final TPM pillar and implements a methodology to drive towards the achievement of zero accidents. It is important to note that this is not just safety related but covers zero accidents, zero overburden (physical and mental stress and strain on employees) and zero pollution.

Selecting the most important device machine shop

3. Results

In this paper, the weights of criteria have been calculated by applying the AHP and TOPSIS methods. Results are as follow.

SPEED	A1	A2	A3	A4	A5	suP P= aij/∑aij	The relative weight W
A1	0.121	0.121	0.294	0.111	0.111	0.758/5	0.151
A2	0.121	0.121	0.294	0.111	0.111	0.758/5	0.151
A3	0.024	0.024	0.058	0.111	0.111	0.328/5	0.065
A4	0.121	0.121	0.058	0.111	0.111	0.522/5	0.104
A5	0.609	0.609	0.294	0.555	0.555	2.622/5	0.524

ACCURACY	A1	A2	A3	A4	A5	suP P= aij/∑aij	the relatvie weight W
A1	0.034	0.017	0.070	0.009	0.009	0.14/5	0.028
A2	0.103	0.051	0.070	0.456	0.009	0.689/5	0.137
A3	0.310	0.462	0.639	0.456	0.445	2.312/5	0.462
A4	0.241	0.007	0.090	0.O65	0.445	0.848/5	0.169
A5	0.310	0.462	0.127	0.013	0.089	1.001/5	0.200

SAFETY	A1	A2	A3	A4	A4	suP P= aij/∑aij	The relative weight W
A1	0.176	0.09	0.142	0.043	0.066	0.517/5	0.103
A2	0.176	0.09	0.142	0.043	0.066	0.517/5	0.103
A3	0.529	0.272	0.428	0.391	0.6	2.22/5	0.444
A4	0.058	0.272	0.142	0.130	0.066	0.668/5	0.133
A5	0.058	0.272	0.142	0.391	0.2	1.063/5	0.212

QUALITY	A1	A2	A3	A4	A5	suP P= aij/∑aij	The relative weight W
A1	0.041	0.111	0.068	0.015	0.021	0.256/5	0.051
A2	0.013	0.037	0.068	0.015	0.021	0.154/5	0.03
A3	0.369	0.333	0.616	0.538	0.755	2.611/5	0.522
A4	0.287	0.259	0.123	0.107	0.05	0.817	0.163
A5	0.287	0.259	0.123	0.323	0.151	1.153/5	0.23

PRICE	A1	A2	A3	A4	A5	suP P= aij/∑aij	the relative weight W
A1	0.103	0.200	0.076	0.200	0.121	0.72/5	0.144
A2	0.034	0.066	0.076	0.066	0.073	0.315/5	0.063
A3	0.517	0.333	0.384	0.330	0.365	1.929/5	0.385
A4	0.034	0.066	0.076	0.066	0.073	0.315/5	0.063
A5	0.310	0.333	0.384	0.333	0.365	1.725/5	0.335

	C1+	C2+	C3+	C4+	C5-
A1	0.028	0.151	0.103	0.051	0.144
A2	0.137	0.151	0.103	0.030	0.063
A3	0.462	0.065	0.444	0.522	0.385
A4	0.169	0.0104	0.133	0.163	0.063
A5	0.0200	0.524	0.212	0.230	0.345

$$\times \begin{bmatrix} \mathbf{0.292} \\ \mathbf{0.095} \\ \mathbf{0.292} \\ \mathbf{0.297} \\ \mathbf{0.04} \end{bmatrix}$$

A1=(0.028*0.292)+(0.151*0.09)+(0.103*0.292)+(0.051*0.297)+(0.144*0.04)=0.073
A2=(0.137*0.292)+(0.151*0.095)+(0.103*0.292)+(0.03*0.297)+(0.063*0.04)=0.095
A3=(0.462*0.292)+(0.065*0.095)+(0.444*0.292)+(0.522*0.297)+(0.385*0.04)=0.441
A4=(0.169*0.292)+(0.0104*0.095)+(0.133*0.292)+(0.163*0.297)+(0.063*0.04)=0.140
A5=(0.0200*0.292)+(0.524*0.095)+(0.212*0.292)+(0.23*0.297)+(0.34*0.04)=0.199

AHP W= (0.073,0.095,0.441,0.140,0.199)

X_{ij}^{-}	Likert – scale	X_{ij}^{+}
Very little	9	Very much
Low	7	High
Average	5	Average
High	3	Low
Very much	1	Very little

$$\mathbf{n_{ij}} = \frac{\mathbf{a_{ij}}}{\sqrt{\mathbf{a_{ij}^2}}}$$

Topis	C1+	C2+	C3+	C4+	C5-
A1	0.330	0.641	0.589	0.703	0.361
A2	0.330	0.498	0.252	0.502	0.601
A3	0.594	0.213	0.252	0.904	0.120
A4	0.462	0.213	0.421	0.502	0.601
A5	0.462	0.498	0.589	0.703	0.361

$$\times \begin{bmatrix} \mathbf{0.073} \\ \mathbf{0.095} \\ \mathbf{0.441} \\ \mathbf{0.140} \\ \mathbf{0.199} \end{bmatrix}$$

Topis	C1+	C2+	C3+	C4+	C5-
A1	0.024	0.06	0.259	0.098	0.071
A2	0. 024	0.047	0.111	0.07	0.119
A3	0.043	0.020	0.111	0.126	0.023
A4	0.033	0.213	0.421	0.07	0.119
A5	0.033	0.047	0.259	0.098	0.071

W = (0.073,0.095,0.441,0.140,0.199)
V_1^{+} = (0.043,0.06,0259,0.126,0.23)
V_1^{-} = (0.024,0.02,0.111,0.07,0.119)

$\boldsymbol{D1}$+= $\sqrt{(\mathbf{0.024-0.043})^2+}$ (0.060-0.060)^2+(0.259-0.259)^2+(0.098-0.126)^2+(0.071-0.023)^2)=0.057

D1_= $\sqrt{(\mathbf{0.024-0.024})^2+}$ (0.060-0.020)^2+(0.259-0.111)^2+(0.098-0.07)^2+(0.071-0.119)^2)=0.163

D2+= $\sqrt{(\mathbf{0.024-0.043})^2+}$ (0.047-0.06)^2+(0.111-0.295)^2+(0.07-0.126)^2+(0.119-0.023)^2)=0.186

D2_= $\sqrt{(\mathbf{0.024-0.024})^2+}$ (0.047-0.02)^2+(0.111-0.111)^2+(0.07-0.07)^2+(0.119-0.119)^2)=0.027

D3+= $\sqrt{(\mathbf{0.043-0.043})^2+}$ (0.020-0.06)^2+(0.111-0.259)^2+(0.126-0.126)^2+(0.023-0.023)^2)=0.153

D3_= $\sqrt{(\mathbf{0.043-0.024})^2+}$ (0.020-0.020)^2+(0.111-0.111)^2+(0.126-0.070)^2+(0.023-0.119)^2)=0.112

D4+= $\sqrt{(\mathbf{0.033-0.043})^2+}$ (0.020-0.06)^2+(0.185-0.259)^2+(0.070-0.126)^2+(0.119-0.023)^2)=0.139

D4_= $\sqrt{(\mathbf{0.033-0.024})^2+}$ (0.020-0.020)^2+(0.185-0.111)^2+(0.070-0.070)^2+(0.119-0.119)^2)=0.074

D5+= $\sqrt{(\mathbf{0.033-0.043})^2+}$ (0.047-0.06)^2+(0.259-0.259)^2+(0.098-0.126)^2+(0.071-0.023)^2)=0.057

D5_= $\sqrt{(\mathbf{0.033-0.024})^2+}$ (0.047-0.020)^2+(0.259-0.111)^2+(0.098-0.070)^2+(0.071-0.119)^2)=0.160

$$\text{CL1}= \frac{\mathbf{d_1^-}}{\mathbf{d_1^+ + d_1^-}} = \frac{\mathbf{0.163}}{\mathbf{0.057+0.163}} = 0.74$$

$$CL2= \frac{d_2^-}{d_2^+ + d_2^-} = \frac{0.0.027}{0.186+0.027} = 0.126$$

$$CL3= \frac{d_3^-}{d_3^+ + d_3^-} = \frac{0.112}{0.153+0.112} = 0.422$$

$$CL4= \frac{d_4^-}{d_4^+ + d_4^-} = \frac{0.074}{0.139+0.074} = 0.347$$

$$CL5= \frac{d_5^-}{d_5^+ + d_5^-} = \frac{0.160}{0.057+0.160} = 0.737$$

$$A_5 > A_3 > A_4 > A_2 > A_1$$

The weights for each option are: ″A1″ (0.74), A2″ (0.126), ″ A3″ (0.422), A4″ (0.347), ″A5″ (0. 737).

5. Conclusion

An optimal maintenance strategy plays a pivotal role in increasing availability and reliability of plants equipment. Also it can reduce unnecessary maintenance investment. The evaluation of maintenance strategies for manufacturing company is a typical multiple criteria decision-making problem (Wang, et al., 2007). These criteria can be both qualitative and quantitative ones. Also, the relations between these criteria and sub criteria may affect the selecting convenient maintenance strategy. The main contribution of this study is to establish maintenance strategy selection model by combining detailed factors and sub-factors and considering the relationship between factors. by labors and reduction in late deliveries are the most important sub-factors for maintenance strategy evaluation. This study has revealed that the most suitable maintenance strategy Aviation Industry Corporation of Iran World-class Maintenance Systems (WMS), followed by Total Productive Maintenance (TPM) and Traditional maintenance.

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