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APPLICATION OF TOPSIS APPROACH FOR PRIORITIZATION OF WORLD CLASS MANUFACTURING IMPLEMENTATION BARRIERS

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Abstract

World class manufacturing is present day need for survival for any industry in this fast pacing world of competition in order to prove its worth by surpassing other competitors and carving out a niche for itself that can set examples for others to follow. However, there are many barriers that obstruct the attainment of world class manufacturing. It becomes indispensable to have a thorough knowledge of these barriers and the severity of their impact on achieving world class manufacturing. In view of this, the main objective of the present research work is to identify and prioritize the barriers of World Class Manufacturing (WCM) practice implementation. The WCM barriers have been identified from the literature analysis. Prioritization of WCM barriers has been carried out by utilizing the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) approach. TOPSIS approach helps to identify the prominent barriers in order to abate its effects. This prioritization will help the industry management to get prepared for all kinds of possible roadblocks and results in lesser adverse effects due to better planning.

Keywords: *World class manufacturing (WCM), barriers, TOPSIS approach.*

1. Introduction

World class manufacturing refers to a decided collection of standard concepts, technologies and implementations that need to be adopted in regular practice by industries in order to surpass their global competitors and to set an example of standard performance in the international market (Hendry, 1998; Dev and Attri, 2015; Singh and Grewal, 2016; Sandeep et al, 2016). The changing market trends, increased international competition, accelerated rate of globalization, higher flexibility needs and quality conscious customers necessitate the need to review the conventional methodologies of organizations (Gharakhani, 2011; Murino et al, 2012; Oliveira et al, 2017). Now days, modern manufacturing organizations are paying adequate attention to world class manufacturing practice to cope with the present day competition.

World class manufacturing (WCM) has its foundation on three major factors, namely, customer oriented approach, adaptive approach and quality consciousness and six fundamental pre requisites, namely, active employee involvement, supply management cooperation, product development improvement, more technological reliability, environmental and employee safety and corporate citizens (Salaheldin and Eid, 2007; Dev and Attri, 2015). An intensive introspection of existing methodologies is a pre requisite for any industry aiming for WCM. However, the extent to which an industry achieves WCM cannot be judged by same theories without taking into consideration the variations offered by each industry in terms of its methodology and area of performance (Hendry, 1998). WCM is not only based upon conceptual theories but also incorporates the key elements of modern production technologies, namely, Just in Time, Total Quality Management etc. (Salaheldin and Eid, 2007).

However, execution of concepts of WCM is much more challenging than planning for it. There are several roadblocks in the path of its implementation. Some firms are successful in full fledged implementation of WCM, whereas, other firms are unable to even get a small success in this aspect (Hendry, 1998). Few of these barriers may be arising from within the industries while few others may be due to other factors residing outside. Unless the industry is well prepared and determined to make an endeavor to overcome these barriers with a balanced application of concepts as well as strategies, they may continue posing a threat to achievement of a world class performance.

In the present work, WCM barriers have been identified from the literature analysis of WCM. Afterwards, TOPSIS method is selected to rank the barriers as per the extent of hindrance they cause in achieving WCM. This prioritization facilitates in focusing on the major barriers and strategically planning to resolve them. TOPSIS is a multi-criteria decision analysis method to choose a solution from a collection of given alternative solutions.

2. Literature Survey

Section 2 illustrates the literature review on the world class manufacturing practice implementation.

Salaheldin and Eid (2007) studied the application of principles of World Class Manufacturing in a manufacturing set up of Egypt in order to recognize the promoters and inhibitors of WCM implementation. Moreover, in this paper authors stated that educational lag and inefficient strategy are main culprits responsible for inhibiting the implementation of WCM.

Murino et al. (2012) presented a case study on the application of WCM to an Italian Automotive Manufacturing Company and after analyzing the results obtained, authors concluded that safety should be the prime focus in order to protect the human resources and hence, to eliminate burdensome costs.

Dev and Attri (2015) used the results of a questionnaire combined with thorough literature review to identify the various barriers of WCM and divided them into five main categories, namely, behavioral, non behavioral, human and cultural, tactical and performance appraisal barriers. Graph Theory Approach was then applied to these barriers in order to analyze their effects on implementation of WCM.

Hendry (1998) proposed that concepts of WCM are generally targeted for mass producers and for customer oriented service sectors as per literature survey.

Gharakhani (2011) utilized fuzzy analytical hierarchy process to rank the barriers of WCM for Iranian companies. Authors deduced that the incompetent managers with lack of short sightedness, uncooperative and untrained workforce with lack of innovation, less support of technology, poor workplace culture and unstable management are very important barriers in WCM implementation.

Singh and Grewal (2016) adopted ISM and MICMAC method to study the roadblocks of WCM that hinders its application in industries and based on the application of these methods, classified the barriers into four groups, that is, autonomous, linkage, dependent and independent barriers.

Sandeep et al. (2016) analyzed the prevalent practices of WCM and evaluated the barriers that obstruct the attainment of WCM. The barriers identified are ineffective cooperation from higher management, lack of expertise, communication gap, poor driving force, inefficient planning and cultural resistance.

Dubey and Mitnala (2017) performed extensive literature review on WCM and concluded that to increase the rate of implementing WCM, it is important to consider few factors such as recognizing the sources of errors, elimination of these sources and taking proper measures to avoid such errors in future.

Midor (2012) studied implementation of WCM in an automotive industry and suggested that for achieving WCM, there has to be a proper review of losses occurring and the processes resulting in wastage should be found and reviewed hence reducing costs. Authors also suggested that for attaining WCM, it is required that manufacturing and logistics should be properly planned and restructured with an efficient auditing.

Oliveira et al. (2017) illustrated that there are three factors which can be considered in order to check competence of Brazilian companies in attaining WCM, namely, human resource, lean manufacturing and good environmental practices.

On the basis of literature analysis, barriers of WCM implementation (mentioned in Table 1) has been identified.

Table 1: Barriers of WCM practices implementation

Poor management support	WB1
Poor employee support	WB2
Less emphasis on continuous improvement	WB3
Poor working environment	WB4
Less emphasis on customer needs	WB5
Lack of education and training	WB6
Poor motivational strategies	WB7

Poor planning	WB8
Poor monitoring & feedback system	WB9
Financial constraints	WB10
Poor utilization of tool, techniques and methodologies	WB11
Poor communication	WB12
Less flexibility to adopt changes	WB13
Lack of team work and coordination among employees	WB14
Less educated employees	WB15

3. TOPSIS Methodology

TOPSIS approach is widely used for the prioritization or ranking of different attributes related to a particular issue or problem. The steps involved in TOPSIS methodology is as follows (Rao, 2007; Dixit and Raj, 2018):

- Decide the main aim of applying this approach and fix the required attributes.
- Form a decision matrix represented by M_{ij} where row and columns are represented by i and j, i.e., it is a matrix represented by (i x j). For this matrix, any attribute represented by row i finds its corresponding criteria in row j. A standard matrix D_{ij} is given for a total of n number of alternative solution and total c criteria by the mathematical formula:

$$D_{ij} = \frac{M_{ij}}{\sqrt{\sum_{i,j=1}^{n,c}\left(M_{ij}^{2}\right)}} \tag{1}$$

- Allocate weight to each criteria such that $\sum w_k = 1$, where w denotes the weight that represents the significance held by these criteria. Normalized weight is given as:

$$Normalized\ weight = \frac{Sum\,total\ of\ individual\ significance}{Total\ significance} \tag{2}$$

- Multiply elements of standard matrix with its corresponding assigned weight to get a resultant weighted normalized matrix.

$$W_{ij} = w_k D_{ij} \tag{3}$$

- Select the most desirable (ideal) and least desirable (nadir) attribute i.e., the maximum and minimum values of rating in weighted normalized matrix, represented by P and N respectively.
- Calculate the distance of weighted matrix from ideal and nadir attribute.

$$D_p = \sqrt{\sum_{j=1}^{k}\left(W_{ij}P\right)^2} \tag{4}$$

$$D_n = \sqrt{\sum_{j=1}^{k}\left(W_{ij}N\right)^2} \tag{5}$$

- Composite performance score, Y, that is, closeness of an attribute to an ideal solution, can be calculated as:

$$Y = \frac{D_n}{D_n + D_p} \tag{6}$$

- On the basis of values of Y, alternatives can be arranged in a particular order in which max Y refers to most favorable and smallest Y value refers to least favorable solution.

3. Application of TOPSIS on WCM barriers prioritization

Based on thorough literature review, a list of barriers is finalized for application of TOPSIS method. A questionnaire was articulated and administered to different manufacturing organizations situated in NCR region. The respondents were asked to rate the barriers of WCM implementation on the scale of 1-5. Total 25 filled questionnaire responses were received. The survey data is represented in Table 2.

Table 2: *Collected survey data*

Notation	Rating				
	5	4	3	2	1
	Most Important	**Very Important**	**Important**	**Somewhat important**	**Least important**
WB1	10	8	5	2	0
WB2	10	7	6	2	0
WB3	9	7	8	1	0
WB4	7	7	6	5	0
WB5	9	8	5	3	0
WB6	9	7	8	1	0
WB7	6	9	8	2	0
WB8	7	10	5	3	0
WB9	8	8	7	2	0
WB10	3	5	9	4	4
WB11	5	5	8	6	1
WB12	5	8	8	3	1
WB13	8	8	6	3	0
WB14	7	9	6	3	0
WB15	3	3	10	8	1

Afterwards, data available in Table 2 has been normalized by using equation (1) and is presented in Table 3.

Table 3: *Normalized survey data*

Barriers of WCM implementation	Rating				
	5	4	3	2	1
	Most Important	**Very Important**	**Important**	**Somewhat important**	**Least important**
WB1	3.4879	2.2122	0.9015	0.2801	0.0000
WB2	3.4879	1.6937	1.2982	0.2801	0.0000
WB3	2.8252	1.6937	2.3079	0.0700	0.0000
WB4	1.7091	1.6937	1.2982	1.7504	0.0000
WB5	2.8252	2.2122	0.9015	0.6301	0.0000
WB6	2.8252	1.6937	2.3079	0.0700	0.0000
WB7	1.2556	2.7998	2.3079	0.2801	0.0000
WB8	1.7091	3.4565	0.9015	0.6301	0.0000
WB9	2.2323	2.2122	1.7670	0.2801	0.0000
WB10	0.3139	0.8641	2.9209	1.1202	3.6707
WB11	0.8720	0.8641	2.3079	2.5205	0.2294
WB12	0.8720	2.2122	2.3079	0.6301	0.2294
WB13	2.2323	2.2122	1.2982	0.6301	0.0000
WB14	1.7091	2.7998	1.2982	0.6301	0.0000
WB15	0.3139	0.3111	3.6061	4.4809	0.2294

In next step of TOPSIS methodology, weights of each attribute/criteria are computed by using equation (2) and are represented in Table 4.

Table 4: *Rating weightage*

Rating	Most Important	Very Important	Important	Somewhat important	Least important
Instance of occurrence	106	109	105	48	7
Importance total	530	436	315	96	7
Normalized weight for importance	0.3829	0.3150	0.2276	0.0694	0.0051

Then, elements of standard matrix are multiplied with its corresponding assigned weight to get a resultant weighted normalized matrix (Table 5).

Table 5: *Weighted normalized data matrix*

Barriers of WCM implementation	Rating				
	5	4	3	2	1
	Most Important	Very Important	Important	Somewhat important	Least important
WB1	1.3357	0.6969	0.2052	0.0194	0.0000
WB2	1.3357	0.5336	0.2955	0.0194	0.0000
WB3	1.0819	0.5336	0.5253	0.0049	0.0000
WB4	0.6545	0.5336	0.2955	0.1214	0.0000
WB5	1.0819	0.6969	0.2052	0.0437	0.0000
WB6	1.0819	0.5336	0.5253	0.0049	0.0000
WB7	0.4808	0.8820	0.5253	0.0194	0.0000
WB8	0.6545	1.0889	0.2052	0.0437	0.0000
WB9	0.8548	0.6969	0.4022	0.0194	0.0000
WB10	0.1202	0.2722	0.6648	0.0777	0.0186
WB11	0.3339	0.2722	0.5253	0.1748	0.0012
WB12	0.3339	0.6969	0.5253	0.0437	0.0012
WB13	0.8548	0.6969	0.2955	0.0437	0.0000
WB14	0.6545	0.8820	0.2955	0.0437	0.0000
WB15	0.1202	0.0980	0.8208	0.3108	0.0012

Afterwards, most desirable (ideal) attribute is selected in such a way that it has the maximum values of rating in weighted normalized matrix, represented by P. Table 6 shows ideal attributes.

Table 6: *Table of ideal attribute*

	max Wi1	max Wi2	max Wi3	max Wi4	max Wi4
P	1.3357	1.0889	0.8208	0.3108	0.0186

Then, least desirable (nadir) attribute is selected in such a way that it has the minimum values of rating in weighted normalized matrix, represented by N. Table 7 shows nadir attributes.

Table 7: *Table of nadir attribute*

	min Wi1	min Wi2	min Wi3	min Wi4	min Wi5
N	0.1202	0.0980	0.2052	0.0049	0.0000

Subsequently, distance of weighted matrix from ideal and nadir attribute is calculated using equations (4) and (5) and the reading is tabulated

under the denotations D_p and D_n, respectively:

Table 8: *Distance of ideal and nadir alternative*

from weighted data

Barriers of WCM implementation	Notation	D_p	D_n
Poor management support	WB1	0.7860	1.3551
Poor employee support	WB2	0.8183	1.2944
Less emphasis on continuous improvement	WB3	0.7444	1.1032
Poor working environment	WB4	1.0414	0.7049
Less emphasis on customer needs	WB5	0.8177	1.1336
Lack of education and training	WB6	0.7444	1.1032
Poor motivational strategies	WB7	0.9727	0.9205
Poor planning	WB8	0.9564	1.1264
Poor monitoring & feedback system	WB9	0.8033	0.9682
Financial constraints	WB10	1.4910	0.4972
Poor utilization of tool, techniques and methodologies	WB11	1.3329	0.4554
Poor communication	WB12	1.1472	0.7130
Less flexibility to adopt changes	WB13	0.8559	0.9529
Lack of team work and coordination among employees	WB14	0.9244	0.9538
Less educated employees	WB15	1.5683	0.6874

Then, composite performance score, Y, which is, closeness of an attribute to an ideal solution, is computed using equation (6). Table 9 shows the composite performance score.

Table 9: *Composite performance score*

Barriers of WCM implementation	Notation	Y
Poor management support	WB1	0.6329
Poor employee support	WB2	0.6127
Less emphasis on continuous improvement	WB3	0.5971
Poor working environment	WB4	0.4037
Less emphasis on customer needs	WB5	0.5809
Lack of education and training	WB6	0.5971
Poor motivational strategies	WB7	0.4862
Poor planning	WB8	0.5408
Poor monitoring & feedback system	WB9	0.5465
Financial constraints	WB10	0.2501
Poor utilization of tool, techniques and methodologies	WB11	0.2547
Poor communication	WB12	0.3833
Less flexibility to adopt changes	WB13	0.5268
Lack of team work and coordination among employees	WB14	0.5078
Less educated employees	WB15	0.3047

At last, data obtained in Table 9 are arranged in the descending order according to the values of Y. This ranking puts emphasis on the barrier that is most inhibiting and differentiates it from the less affecting ones. Table 10 shows the ranking of barriers of WCM implementation.

Table 10: Ranking the attributes from largest to smallest value

Barriers of WCM implementation	Notation	Y
Poor management support	WB1	0.6329
Poor employee support	WB2	0.6127
Less emphasis on continuous improvement	WB3	0.5971
Lack of education and training	WB6	0.5971
Less emphasis on customer needs	WB5	0.5809

Table 8 shows the distance of distance of ideal and nadir alternative from weighted data.

Poor monitoring & feedback system	WB9	0.5465
Poor planning	WB8	0.5408
Less flexibility to adopt changes	WB13	0.5268
Lack of team work and coordination among employees	WB14	0.5078
Poor motivational strategies	WB7	0.4862
Poor working environment	WB4	0.4037
Poor communication	WB12	0.3833
Less educated employees	WB15	0.3047
Poor utilization of tool, techniques and methodologies	WB11	0.2547
Financial constraints	WB10	0.2501

5. Conclusion

In the present paper, barriers of world class manufacturing practices have been identified and analyzed by using TOPSIS methodology. TOPSIS methodology has been frequently used multi-criteria decision making methodology for the ranking or prioritization of attributes of an issue under consideration.

Results of TOPSIS methodology reveal that poor management support is the most significant barrier in the implementation of WCM practices. Then, it is followed by less emphasis on continuous improvement, lack of education and training, less emphasis on customer needs, poor monitoring & feedback system, poor planning, less flexibility to adopt changes, lack of team work and coordination among employees, poor motivational strategies, poor working environment, poor communication, less educated employees, poor utilization of tool, techniques and methodologies. Financial constraints are the least significant barrier in the implementation of WCM practices in manufacturing organizations. The management/decision makers of manufacturing organizations may use the results of this study for the proper handling of barriers in the implementation of WCM practices.

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