Received 24 September 2019
Revised 18 October 2019
Accepted 21 October 2019

An investigation of barriers to waste management techniques implemented in Indian manufacturing industries using analytical hierarchy process

Harsimran Singh Sodhi
Department of Mechanical Engineering, Chandigarh University, Gharuan, India
Doordarshi Singh
Department of Mechanical Engineering, BBSBEC, Fatehgarh Sahib, India, and
Bikram Jit Singh
Department of Mechanical Engineering,
Maharishi Markandeshwar Deemed to be University, Mullana, Ambala, India

Abstract

Purpose – The purpose of this paper is to identify the various barriers in the implementation of waste management techniques in manufacturing organizations.
Design/methodology/approach – In this study, 121 SMEs of the manufacturing sector have been extensively surveyed, to assess the relative impact of barriers in the waste management technique in a manufacturing organization. Further, analytical hierarchy process (AHP) has been used to identify the most significant barriers.
Findings – Major barriers in the implementation of a waste management technique in a manufacturing organization have been identified and their weightage has been calculated through the AHP model.
Originality/value – This study will assist the floor managers in manufacturing organizations to identify the major barriers and to plan accordingly for the adequate implementation of waste management technique.

Keywords Barriers, Waste management

Paper type Research paper

1. Introduction

Waste is having a great significance on the economic losses of an industrial organization. Uma (2013) discussedthat waste reduction is very effective for eliminating problems related to social progress and economy of the developing countries. Myrdal *et al.* (2017) rightly described the relationship between industrialization and economic development when he observed that "the manufacturing industry represents, in a sense, a higher stage of production in advanced countries." Vinesh and Geoff (2012), inhis research, explained that present-day industrial environmental conditions are very much affected by the regularly rising rate of scrap and wastage of available resources which are the cause of shredding their profits. Flashy *et al.* (2014) purposed value Stream mapping (VSM) strategy, which includes flowcharting the men, material, machines, different procedure components that are included with a procedure or change demonstrating huge impact of wastage on the economy of manufacturing industries. Augusto *et al.* (2009) implemented VSM in carriage building shop and as a result, he found a reduction of 8 percent of wastage of resources on the shop floor. Singh *et al.* (2013) concentrated on the lean manufacturing framework, which has been recognized by the Indian industry as a proficient framework in upgrading implemented waste management technique for the purpose of scrap reduction. Tamizharasi *et al.* (2014), in his research, examined about different waste management methods utilized in Indian

World Journal of Science, Technology and Sustainable Development
Vol. 17 No. 1, 2020
pp. 58-70

2042-5945
DOI 10.1108/WJSTSD-09-2019-0069

SMEs' proposed advantages of executing Lean Manufacturing idea and spotlights on VSM for the purpose of scrap reduction in Indian manufacturing organizations. Kumar *et al.* (2018) distinguished different lean manufacturing in assembling frameworks recognized by Indian industry as a competent framework in upgrading hierarchical execution by concentrating on disposal of waste management improving overall process of waste management. Kumar *et al.* inspectedthat endeavors have been made to distinguish the obstructions for lean manufacturing execution and after that to build up the connections among these recognized hindrances. While writing the study, he recommended some vital obstructions in the lean execution, an extra couple of hindrances were recognized through discourses with the topic specialists from the business. A complete overview instrument comprising of 30 surveys was then used to assess the significance of various lean execution boundaries. As indicated by Mandar *et al.* (2018), lean standards and lean apparatuses have an overwhelming job in various modern segments in India. Singh and Kumar (2013a, b) made an attempt has been made to applied two phase analytical hierarchy process (AHP) and TOPSIS for measuring the performance of advanced manufacturing technologies. AHP and TOPSIS have been used to compute priority weightage of criterion and ranking of alternates, respectively. The point of lean is to kill the waste found in particular ventures by utilizing the diverse lean instruments. The primary reason for this investigation is to recognize the diverse kinds of lean instruments use in various mechanical divisions. Solanki (2019) tooka shot at assembling procedure of cryogenic vessel, welding absconds, which is a serious issue which prompts significant misfortune to the organizations. To improve the procedure, it is required to actualize quality administration. Ravi (2018) recalled that lean is formed into an administration technique, which improves the general standard of an association by wiping out the wastage. Rojasra (2013) examinedthat small-scale businesses have been developed as a useful asset in giving moderately bigger work alongside agribusiness. Worldwide markets are consistently changing and requesting the result of high caliber and minimal effort. This can be created by utilizing lean assembling, an administration theory that planned to lessen a wide range of squanders at all dimensions of item fabricating in order to decrease the item cost. Krishnan and Madu's (2013) essentialsubject of enthusiasm for their paper is to study and look at the lean devices utilized in the assembling and administration divisions and to arrive at a resolution with respect to patterns in the lean devices received. Bakri (2013) examinedthe fundamental job of total productive management (TPM) in supporting and building up quality improvement activity, for example, lean creation. Exertion was made to examine the distributed research identified with TPM and lean creation.

Lean manufacturing continuously identifies and removes all kinds of scraps. There are various approaches/techniques which aim at identifying various types of scraps and their sources and then drive methodologies to remove them from the systems on a rapid basis.

AHP is widely used for dealing with multi-criteria decision-making (MCDM) problems (Sodhi *et al.*, 2013). AHP is among the most widely used decision-making approaches in the world today. Singh *et al.* (2013) described and elaborated on the process. AHP is based on the well-defined mathematical structure of consistent matrices and their associated right eigenvector's ability to generate true or approximate weights.

For solving MCDM problems, the goal of the decision process is broken out into its constituent parts, moving from the general to the specific perspective. In its simplest form, this structure must include a goal, attribute and alternative levels prearranged into a hierarchy. Each criterion would then be further divided into an appropriate level of detail, recognizing that the more criteria included, the less important each individual criterion may become. Once the hierarchy has been formulated, decision makers judge the importance of each criterion in pair-wise comparisons. The final scoring is on a relative basis, comparing the importance of one decision alternative to another.

2. Literature review

Literature has been extensively reviewed on waste management techniques and barriers to the implementation of these techniques.

2.1 Waste management techniques

Literature based upon waste management has been reviewed and reviles that waste is having a great significance on the economic losses bared by an industrial organization. Uma (2013) discussed that waste reduction in industrialization is a very effective means for solving various economic-related issues and social relevance. Myrdal *et al.* (2017) properly depicted the connection among industrialization and financial improvement when he sees that "the manufacturing industries have a higher phase of generation in cutting edge technologies in developing nations." Vinesh and Geoff (2012), in his research, explained that sustainability is more universally rational and less prescriptive, and concentrated on counteractive action of contamination through control of perilous materials and procedures just as on assurance of eco-frameworks. According to Mandar *et al.* (2013), lean tools and principals have a predominant role in different industrial sectors in India. The aim of lean manufacturing is to eliminate the waste found in respective industries by using the different lean tools. Solanki (2019) worked on the manufacturing process of the cryogenic vessel, welding defects, which is a major problem which leads to major loss to the companies. To improve the process, it is desired to implement quality management. During his practical implementation, he proposed a philosophical and analytical technique by applying the same during the production process. Ravi (2018) stated that lean is developed as a management method, which improves the overall standard of an organization by eliminating the wastage. Sodhi *et al.* (2019) compared various lean manufacturing tools used in the manufacturing and service sectors. Bakri (2013) investigated the main role of TPM in supporting and establishing quality improvement initiative such as lean production. Singh and Kumar (2013a, b) presented the application of AHP in decision making. The managerial implication of AHP in manufacturing environment has been demonstrated.

2.2 Barriers to waste management implementation

In the present scenario, manufacturing industry is one of the aggressively expanding markets in the developing nation. The augmented demand and consumption of manufactured products are caused owing to the rapid pecuniary growth. The growth is clubbed with urbanization, rapid change in technologies, drop in pricing trends and replenishment of manufactured products with the new one as per the consumer's habits. This has aggravated the manufacturing of products, in order to get maximum output out that waste management is highlyimportant (Sodhi and Singh, 2014). Waste management is strategic for keeping resources circulating. The purpose of circularity of resources is to incorporate the perspectives of industrial symbiosis, service ecosystems, resource-based productivity and functional alignment to help to ensure that societies will function sustainably. There have been a number of barriers in the implementation of appropriate waste management techniques in manufacturing organizations. Kumar *et al.* (2018) presented the key factors for successful implementation of AMT in manufacturing industry. The managerial guidelines are provided to enhance the success probability of AMT implementation. Acknowledging the importance and impact of waste management, manufacturing organizations in the developed nations have designed obligatory regulations for handling waste. Hence, these wastes are exported to the developing nations for recycling, as these nations have weak policies for implementation of waste management techniques in their manufacturing organizations (Sodhi *et al.*, 2012). In the developing nations, there are indefinable remedial measures, vague *ad hoc* roles of stakeholders, and investment of inadequate resource in the waste management sector. These challenges are compounded by social, economic, legal, financial, knowledge and technological weaknesses. Kumar and Singh (2018) analyzed the effect of success factor on potential output of the manufacturing industry. The relation between input and output parameters is presented in order to enhance the performance of manufacturing industry.

Barriers to the implementation of waste management techniques effectively in manufacturing organizations identified in literature are listed in Table I.

3. Design of study

Extensive literature based on various waste management techniques has been reviewed. From the literature, it has been noticed that there a number of barriers in the implementation of waste management techniques in the manufacturing organizations. A questionnaire on a Likert scale of 5 was prepared to access the level of barriers in manufacturing organizations. Further, this questionnaire was sent to various researchers, academicians and industrial practitioners for the purpose of a pilot survey and validation. After getting the necessary inputs, the questionnaire was finalized. The step-by-step methodology adopted for this study is illustrated in Figure 1.

The manufacturing SMEs were identified from all over India for data collection. Further, the finalized questionnaire was sent to 650 SMEs to capture the voice of industrial

S. No.	Barrier
1	Inadequate training programs
2	Lack of information of waste management techniques
3	Problems with compatibility of Tools and Techniques
4	Lack of trained professionals
5	Skill deficiency for waste management technique
6	Disruptions during implementation
7	Lack of co-operation and understanding
8	Workers resistance to change
9	Lack of individual effort
10	Lack of relevant experience at each level

Table I. Barriers to the implementation of waste management techniques

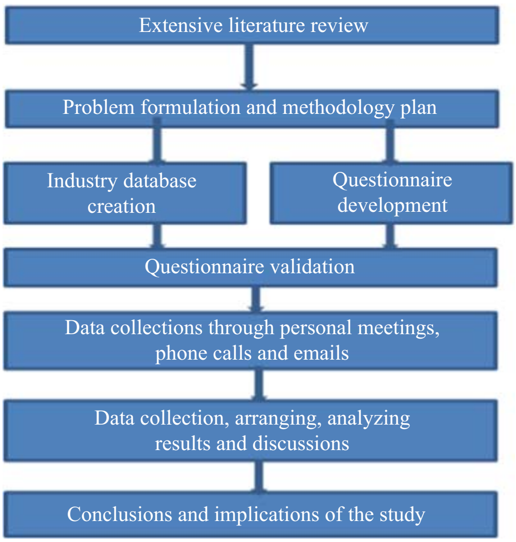

Figure 1. Methodology adopted for the study

organizations regarding the success of implemented waste management technique. Out of this, 130 had replied, and a response rate of 21 percent. Elimination of unusable responses resulted in 121 responses finally for the further analysis work. This compares well with the response rates for studies in operations management(Handfield and Pannessi, 1995; Oberoi *et al.*, 2008; Singh *et al.*, 2013); it has been found that various SMEs across India are using different waste management techniques like lean manufacturing, Six Sigma, 5s, TPM, LSS, etc. A spreadsheet was prepared for compiling the voice of various SMEs regarding the success of implemented waste management technique in a single sheet.

The focus of the study is on small- and medium-scale manufacturing enterprises across India. The data collected for the present research involves 63 responses from small-scale and 58 responses from medium-scale organizations, shown in Figure 2.

4. AHP for assessing barriers to waste management techniques

The AHP is a method to evaluate the weights of cretria. The AHP has been used widely in a variety of complex decision-making problems related to strategic planning of organizational resources, the evaluation of strategic alternatives or the justification of new manufacturing technology. An earlier survey provided over 200 known applications of the AHP. AHP has also been used widely in marketing, finance, education, public policy, economics, medicine and sports. The AHP has been applied in a variety of formats such as: the design tool for large-scale systems or composite ratio, the instrument for pair-wise comparison in the application of artificial neural network or the primary structure of decision-support systems. As a convenient methodology, the AHP approach has been used to examine the weighting vector within the reference framework and search reference direction in a visual interactive system, and to identify objective coefficient and parameter values in multiple-objective LP problems (Hajmohammad *et al.*, 2013). Chiarini (2013) developeda model of TPM decision-making using the AHP. A framework that employs the AHP for justification of TPM implementation in manufacturing organizations was presented. Chen and Lyu (2009) employedAHP and Taguchi loss function to develop a decision model to help decision makers with selection of the appropriate supplier for the outsourcing purposes. It was observed that although outsourcing provides certain benefits for the company, it carries with it several risks as well.

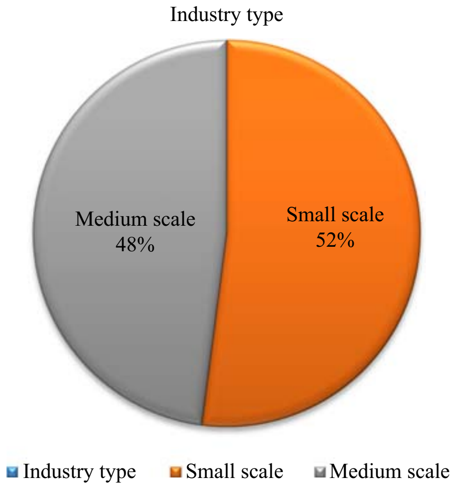

Figure 2. Breakdown of responses

4.1 Describing model structure and formulation of hierarchy

Figure 3 indicates the results of the study. The levels of barriers to waste management techniques in manufacturing organizations have been shown graphically. Identification of the important attributes (barriers in this case) for AHP requires a thorough analysis of the problem. For current study, the selection of attributes has been determined through literature survey and discussions which were held with experts during industrial visits and with academicians working in the same area. Ten barriers with highest scores as shown in Figure 3 have been chosen and their description is given in Table II.

Table II shows a simple decision matrix consisting of ten criteria, i.e. inadequate training programs, lack of information of waste management techniques, problems with compatibility of tools and techniques, lack of trained professionals, skill deficiency for waste management technique, disruptions during implementation, lack of co-operation and understanding, workers resistance to change, lack of individual effort and lack of relevant experience at each level. Each criterion is having five alternatives with each alternative having its own value of criteria associated with them. The value in the pair-wise matrix will depend upon the decision maker or the person who is responding to the questionnaire which is circulated in the manufacturing organization. The sum of each value calculated is shown at the bottom of each column of the table. A pair-wise simple matrix is represented in Table II, which gives relative importance of various attributes with respect to the barriers associated with the implementation of the waste management technique in the manufacturing organizations.

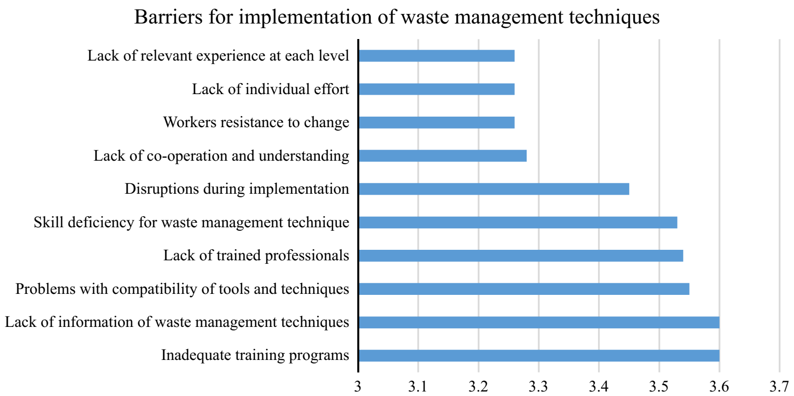

Figure 3. Levels of barriers in manufacturing organizations

Attribute	Abbreviation
Inadequate training programs	ITP
Lack of information of waste management techniques	LOIWSM
Problems with compatibility of Tools and Techniques	PWTT
Lack of trained professionals	LTP
Skill deficiency for waste management technique	SDWSM
Disruptions during implementation	DDI
Lack of co-operation and understanding	LOCU
Workers resistance to change	WRC
Lack of individual effort	LIE
Lack of relevant experience at each level	LREEL

Table II. Description of the attributes chosen

4.2 Paired comparison of different sub-objectives

This pair-wise comparison matrix is created with the help of scale of relative importance. Paired comparison is based on the idea that a complex issue can be effectively examined if it is hierarchically decomposed into its parts. The elements are compared with each other, thus providing an opportunity for a pair-wise comparison for evolving the structure into an $n \times n$ reciprocal judgment matrix. In the matrix, one begins with an element on the left and compares how much more important it is than an element on top. When compared with itself, the ratio is one. When compared with another element, if it is more important than that element, an integer value, as discussed below, is used. If, however, it is less important, then the reciprocal of the previous integer value is used. In either case, the reciprocal value is entered in the transpose position of the matrix. Thus, only n $(n-1)/2$ judgments are considered, where n is the total number. In this comparison, the importance of the ith sub-objective is compared with jth sub-objective is calculated. A scale of 1–9 is used for giving the judgment value according to the following guidelines:

- 1 if i and j are equally important;
- 3 if i is weakly more important than j;
- 5 if i is strongly more important than j;
- 7 if i is very strongly more important than j; and
- 9 if i is absolutely more important than j.

Values of 2, 4, 6 and 8 are used to compromise between two judgments.

The length of the pair-wise matrix is equally equivalent to the number of criteria used in the decision-making process. Here, we have a 10×10 matrix as we have ten criteria, i.e. inadequate training programs, lack of information of waste management techniques, problems with compatibility of tools and techniques, lack of trained professionals, skill deficiency for waste management technique, disruptions during implementation, lack of co-operation and understanding, workers resistance to change, lack of individual effort and lack of relevant experience at each level. After a pair-wise comparison matrix is obtained, the next step is to get the value of the normalized matrix. The normalized matrix can be obtained by dividing each entry in the column by the sum of entries in column in the pair-wise comparison matrix. Further, the approximate priority weight for each attribute is obtained, as shown in Table IV. The normalized pair-wise matrix is calculated as all the elements of column is divided by the sum of column. As represented in Table IV, the first value of column 1 is divided by the sum of that column, i.e. 2.77 (Table III) and it comes out to be 0.36. In this way, the normalized pair-wise matrix cam be prepared. Criteria weights have been calculated

Table III.
Pair-wise comparison matrix

Attributes or criteria	ITP	LOIWSM	PWTT	LTP	SDWSM	DDI	LOCU	WRC	LIE	LREEL
ITP	1	5	4	7	5	3	5	7	9	5
LOIWSM	0.20	1	0.5	4	3	9	5	7	5	7
PWTT	0.25	2	1	1	7	3	6	9	3	5
LTP	0.14	0.25	1	1	3	5	8	3	5	3
SDWSM	0.2	0.33	0.14	0.33	1	5	7	3	7	9
DDI	0.33	0.11	0.33	0.2	0.2	1	7	9	7	5
LOCU	0.2	0.2	0.16	0.12	0.14	0.14	1	3	5	7
WRC	0.14	0.14	0.11	0.33	0.33	0.11	0.33	1	3	3
LIE	0.11	0.2	0.33	0.2	0.14	0.14	0.2	0.33	1	5
LREEL	0.2	0.14	0.2	0.33	0.11	0.2	0.14	0.33	0.2	1
Total	2.77	9.37	7.77	14.51	19.92	26.59	39.67	42.66	45.2	50

by averaging all the elements in the row and dividing it with the number of elements in it. The sum of all the elements of Table IV comes out to be 0.281.

4.3 Checking for consistency

The weightages of the features are obtained by calculating the eigenvector weights for the judgment matrix. An index of consistency is calculated to provide information on how serious is violations of numerical and transitive consistency. The results could be used to seek additional information and re-examine the data used in constructing the scale in order to improve consistency. The relative weights, which would also present the eigenvalues of criteria, should verify:

$$A \times Wi = \lambda \max \times W \quad i = 1, 2, \ldots, n.$$

The consistency index (CI) is $= (\lambda \max i - n)/(n-1)$, where n is the number of elements being compared and λ is the largest eigenvalue of the judgement matrix. Dividing CI by the random consistency number for the same size matrix, consistency ratio (CR) can be obtained. The value of CR should be around 10 percent or less to be acceptable. In some cases, a maximum value of 20 percent may be tolerated. If CR is not within this range, participants should study the problem and revise their judgement. The average consistencies for different order random matrices are given as shown in Tables V and VI.

4.4 Priority weights for alternatives with respect to attribute

Priority weights to various waste management techniques have been shown in Table VII. Priority weights are used for measuring the preference of the alternative (barriers to waste

Attributes or criteria	ITP	LOIWSM	PWTT	LTP	SDWSM	DDI	LOCU	WRC	LIE	LREEL	Criteria weights
ITP	0.36	0.53	0.51	0.48	0.25	0.11	0.12	0.16	0.19	0.1	0.281
LOIWSM	0.07	0.106	0.064	0.27	0.15	0.33	0.12	0.16	0.11	0.14	0.1522
PWTT	0.09	0.21	0.12	0.068	0.35	0.11	0.15	0.21	0.06	0.1	0.1468
LTP	0.05	0.026	0.12	0.068	0.153	0.188	0.2	0.07	0.11	0.06	0.1045
SDWSM	0.072	0.035	0.018	0.022	0.05	0.188	0.17	0.07	0.15	0.18	0.0955
DDI	0.11	0.011	0.042	0.137	0.01	0.037	0.17	0.21	0.15	0.1	0.0977
LOCU	0.072	0.021	0.02	0.008	0.14	0.005	0.025	0.07	0.11	0.14	0.0611
WRC	0.05	0.014	0.11	0.022	0.007	0.004	0.008	0.23	0.06	0.06	0.0565
LIE	0.039	0.021	0.014	0.013	0.007	0.005	0.005	0.007	0.02	0.1	0.0231
LREEL	0.072	0.014	0.025	0.022	0.005	0.007	0.003	0.007	0.004	0.02	0.0179

Table IV. Normalized matrix along with priority weights

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.42	1.45	1.49

Table V. Random consistency index (RI)

Max eigenvalue λ max	Consistency index	Random consistency index	Consistency ratio
Values	0.487	1.49	0.032

Table VI. Results of consistency test

Table VII.
AHP of weights

	ITP	LOIWSM	PWTT	LTP	SDWSM	DDI	LOCU	WRC	LIE	LREEL	Weighted sum values (WSV)	Criteria weights (CW)	Priority weights
ITP	0.281	0.761	0.5872	0.7315	0.4775	0.2931	0.3055	0.3955	0.2079	0.0895	4.1297	0.281	4.40
LOIWSM	0.06	0.1522	0.0734	0.418	0.2865	0.8793	0.3055	0.3955	0.1155	0.1253	2.8074	0.1522	18.45
PWTT	0.07025	0.3044	0.1468	0.1045	0.6685	0.2931	0.3666	0.5085	0.0693	0.0895	2.62145	0.1468	7.60
LTP	0.03934	0.03805	0.1468	0.1045	0.2865	0.4885	0.4888	0.1695	0.1155	0.0537	1.93119	0.1045	8.48
SDWSM	0.0562	0.050226	0.020552	0.034485	0.0955	0.4885	0.4277	0.1695	0.1617	0.1611	1.665463	0.0955	7.44
DDI	0.09273	0.016742	0.048444	0.0209	0.0191	0.0977	0.4277	0.5085	0.1617	0.0895	1.483016	0.0977	15.18
LOCU	0.0562	0.03044	0.023488	0.01254	0.01337	0.013678	0.0611	0.1695	0.1155	0.1253	0.621116	0.0611	10.17
WRC	0.03934	0.021308	0.016148	0.034485	0.031515	0.010747	0.020163	0.0565	0.0693	0.0537	0.353206	0.0565	6.20
LIE	0.03091	0.03044	0.048444	0.0209	0.01337	0.013678	0.01222	0.018645	0.0231	0.0895	0.301207	0.0231	10.04
LREEL	0.0562	0.021308	0.02936	0.034485	0.010505	0.01954	0.008554	0.018645	0.00462	0.0179	0.221117	0.0179	12.05

management technique) with respect to an attribute. Thus, if the presence of one attribute (barrier) is strong in the organization, it is more likely to reduce the effectiveness of implemented waste management technique in manufacturing organization, as compared to the other attribute (barrier) which is present but weak. For priority weights, the weight evaluation of each alternative is multiplied in the matrix of evaluation rating by vector of attribute weight and summing over the entire attribute. The next step is to calculate the consistency, i.e. to check whether the calculated value is correct or not. For this, the same pair-wise comparison matrix (Table II) is considered, which is non-normalized. Each value in the column is multiplied with criteria values, i.e. 1 has been multiplied with 0.281 and the value comes out to be 0.281 for ITP. The same procedure is adopted to prepare the matrix in Table VII. Summarizes results of evaluating the possible barriers to implemented waste management technique, with respect to each of ten attributes, are shown in Table VII.

The weighted sum values are calculated by taking the sum of each value in the row. So, by the addition of all the elements in the row, we will get the weighted sum value. Next, the ratio of weighted sum value and criteria weight is calculated for getting the priority weight. Afterwards, the CI is calculated as 0.487 as shown in Table VI. Afterwards, the CR is calculated which comes out to be 0.032, i.e. less than 0.1, which is a standard (Banawi and Bilec, 2014). Therefore, it shows that our matrix is reasonably consistent so we may continue with the process of decision making using AHP. Table VIII represents the weights of an individual barrier which may be considered by the floor manager while considering the barriers to the implementation of waste management technique.

5. Conclusions

Using the AHP approach, vital barriers that oppose the correct implementation of waste management technique in producing organizations are known and analyzed .From the current study, it is been known that inadequate training programs has emerged because it is the major barrier within the adequate implementation of the waste management technique in any manufacturing organization. Except this, a lack of knowledge of waste management techniques is additionally a significant concern within the implementation of waste management technique. Manufacturing organizations are facing issues with compatibility of tools and techniques of assorted waste management techniques. The lack of trained professionals is additionally a reason for concern. The obtained results are quite vital and reveal that each one of the barriers chosen plays a vital role on implementation of the waste management technique. Therefore, these barriers should be overcome so as to attain good implementation of the waste management technique in a manufacturing organization.

Barrier	Percentage
Inadequate training programs	4.40
Lack of information of waste management techniques	18.45
Problems with compatibility of Tools and Techniques	7.60
Lack of trained professionals	8.48
Skill deficiency for waste management technique	7.44
Disruptions during implementation	15.18
Lack of co-operation and understanding	10.17
Workers resistance to change	6.20
Lack of individual effort	10.04
Lack of relevant experience at each level	12.05

Table VIII. Percentage weight of barriers

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Corresponding author
Bikram Jit Singh can be contacted at: chann461@yahoo.com