WORLD CLASS MAINTENANCE PRACTICES: A SURVEY OF INDIAN AUTOMOTIVE INDUSTRIES

Ravi Kumar Goyal and Dr. Kapil Maheshwari

ABSTRACT: The purpose of this paper is to examine the status of world class maintenance practices in Indian automotive industries and for this, a database of 504 automotive industries was identified and a structured questionnaire was designed. The questionnaire was divided into two sections A and B, to assist data interpretation: The aim of the section A was to build general information of participants and firms-position, experience, type of organization, number of employees, mission and vision of the company, type of maintenance system in the organization, etc. Section B was a structured questionnaire developed based on a five point Likert scale for assessing the level of importance of each element given under the 21 World class maintenance frameworks, identified in the literature search. And the responses of industries were analyzed by descriptive analysis and important index analysis.

Keywords: Automobile industries, Critical Success Factors. Descriptive Analysis, Important Index Analysis, Questionnaire, Sample Size, World Class Maintenance

1 INTRODUCTION

The maintenance organization of today, like many departments, is under continued pressure to cut costs, show results, and support the mission of the organization, as it is a logical expectation from the business standpoint. The evolving maintenance operation has been changed with supporting the broader efforts of WCM like six-sigma, lean manufacturing and other major quality initiatives. Wireman (1990) in his book titled World-class maintenance management referred to maintenance planning as the last frontier for organizations. Many firms are realizing a critical need for effective maintenance of production facilities and operating systems. Wireman (1990) emphasized that it is vital for maintenance management to be integrated with corporate strategy to ensure equipment availability, quality products, on-time deliveries, and competitive pricing. The changing need of modern organizations necessitate a re-examination of the role that improved maintenance management plays in achieving key cost and service advantages, leading them to become a world- class manufacturer.

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Hence World-class maintenance is defined as maintenance without waste, where waste is defined as the gaps between the way things are and the way things could be. With poorly organized maintenance operations, this gaps tends to increase continuously, because the focus is on reacting to problems either immediately or on short notice. One requirement to become world-class is to have preventive and proactive measures to avoid the problems.

2 SURVEY INSTRUMENT

Survey instrument development process consists of design of questionnaire and pre-testing of the questionnaire.

2.1 Questionnaire Design

Questionnaire was designed as a research instrument with the intention to make a sincere effort to tap the collective wisdom of the professionals within the automobile industry, who truly care for it, in order to assess the relative importance of variables.

A structured questionnaire was developed on five point Likert scale, where 1 means very low, 2 means low, 3 means medium, 4 means high, 5 means very high. Respondents were requested to rate the degree or extent of practice of each element based on the five point response scale. A typical example is shown below:

Computerized Maintenance Management System	1	2	3	(4)	5

Questionnaire was designed using the 74 variables/items, then; the questionnaire was divided into two sections A and B, to assist data interpretation: The aim of the section A was to build general information of participants and firms-position, experience, type of organization, number of employees, mission and vision of the company, type of maintenance system in the organization, etc.
Section B was a structured questionnaire developed based on a five point Likert scale for assessing the level of importance of each element given under the 21 World class maintenance frameworks, identified in the literature search.

2.2 Questionnaire Pre-testing

The purpose of pre testing is:

- To establish the most appropriate respondents
- To check whether the questions asked in the questionnaire are easy to understand
- To ascertain the effectiveness of the measuring instrument.

Pre-testing was carried out in two stages. In the first stage, a draft of the questionnaire was provided to two academicians and they were requested to critically evaluate the items from the standpoint of item specificity and clarity of construction. Based on critique received, some items were revised to improve their specificity and clarity.
The second pre-test involved administering the questionnaire to industrial professionals. The professionals were asked to complete the revised questionnaire and indicate any ambiguity or other difficulty they experienced in responding to the items, as well as to offer any suggestions they deemed appropriate. The pre-testing was done with the three practitioners from a reputed automobile company. After second pre-test, the questionnaire was reviewed based on expert's comments and phrasings of some items were modified to make the final research instrument more effective.

3 DATA COLLECTION METHODOLOGY

3.1 Sample

Once the instrument is ready, the next step of paramount importance is the selection of sample for which the instrument is designed. A sample is a part of population, which is selected for obtaining the necessary information. Nunnally (1967) argued that, when a measuring instrument is used for data collection, the subjects/samples used should be those for whom the instrument is intended. Since the primary objective is to develop an instrument to measure the participant's (managers and above) perceptions of WCM practices and their items, managers and above are appropriate samples. The General Managers, Directors, Divisional General Managers, Sr. Managers, Chief Engineers are likely to be 'thought' leaders with respect to WCM activities in their organizations, therefore, they are the samples for this study. The selection of samples for this survey has been made based on the following criteria:
Participant should be holding the position not below the level of manager. Participant should be having working experience of at least 5 years. Participant should be fully responsible and involved in automobile sector.

3.2 Sampling Method

The purpose of sampling is to enable one to estimate some unknown characteristics of population. There are nine methods, which could be used for sampling (Metri, 2001): Convenience sampling, Judgment sampling, Snowball sampling, Quota sampling, Simple random sampling, Systematic sampling, Stratified sampling, Cluster sampling and multistage sampling.
All the methods have some advantages and disadvantages. Of these nine methods, snowball sampling is useful in locating members of rare populations by referrals. According to goodman (1961), the snowball sample is a judgment sample that is used to sample special population. Reduced sample sizes and costs are clear cut advantages of snowball sampling. In snowball sampling, initial respondents were selected by probability methods and additional respondents were obtained from information provided by the initial respondents. This method is therefore very appropriate for expert's data collection in which researcher interested in the view of articulate individuals on a particular subject rather than taking a representative probability samples (Metri, 2001). Furthermore, random sampling is representative only when its size is large. In case of small number of sample unit, it may not give representative set of units (Saraph et al., 1989). Also attempting to get a random sample on a relatively new area increase the chance of non-response. Hence snowball sampling method has been considered appropriate and used in this study. The limitation of snowball sampling is that bias may likely to enter into the study because a person who is known to someone (also in sample) has a higher probability of being similar to the first person. If there are differences between those who are widely known by others and those who are not, may be problem with snowball sampling. To reduce the bias, initially 30 respondents were selected by probability method from the various sources, and then additional respondents were obtained from information provided by the initial respondents. The process was continued till the sample reaches the targeted sample size. Descriptive analysis revealed that samples cover the medium and large organizations and also various positions, sectors and organization types. Therefore, snowball sampling for the present study is not biased and has given an adequate representative set of samples.

3.3 Sample Size

Despite the wide spread use of non-probability samples, there is no available theoretical basis for determining the sampling error or sample size (Tull et al., 1997). Observations suggest that non-probability sample size decisions are made by calculating the size either as if were a probability sample or else on an "all-you-can-afford" (Tull et al., 1997). In this case it is very important to find out whether the sample size of 122 is suitable for it. There are many views regarding suitability of sample size. Hutcheson and Sofroniou (1999) recommended at least 150-300 cases. While according to Comery and Lee (1992), a sample of 200 is considered fair. In a review of several studies by Costello and Osborne (2005) reported that 14.7% of studies that they reviewed had STV (subject to variable ratio)< 2:1. In our case it is 1.64 thus cannot be said to be exceptionally small sample size.

3.4 Expert Survey

The method of questionnaire administration was chosen as mail-survey. The questionnaires were mainly targeted to middle or upper level management as explained in previous section. The sample group was contacted either by phone or by e-mail to seek agreement to participate in the survey. Prior appointments were taken from participants to visit their offices/ plants for the survey. The questionnaires were send through e-mail and at some places questionnaires were handed over to the respondents in person.

A database of 504 industries was generated to which the questionnaire was sent. The respondents were asked to assign a score as per the actual level of importance of the elements according to their expertise. The respondents were asked to discuss over telephone or internet with the researcher regarding any doubts or queries they had related to the questionnaire. In totally all companies were contacted through email and subsequently number of reminders were mailed and some people were contacted personally over telephone. In some of the cases where experts were extremely busy, after briefing about the survey, they promised to return the questionnaire as per their convenience within a week or two. These respondents were reminded by phone/ e-mail if they had not returned the questionnaires within the period they promised.

Out of 504 companies, 131 company responses were received. However there were 9 questionnaire which were incomplete and were not valid and hence we had 122 valid responses. The overall response rate was 24.2%. Statistics are shown in the table.

Table 1: Statistics of Responses

Number of questionnaire Sent	504
Responses received	131
Valid responses	122
Response Rate	24.2%

The response rate was satisfactory compared with other surveys, such as those by Shah and Murphy (1995), Saraph et al. (1989), Black and Porter (1996). Bennet and Whittaker (1993) pointed out that the expected response rate for industry is of the order of 25-30%.

Non-response analysis has been conducted to clarify the reasons for not returning completed questionnaire. The method used was direct telephone contact of randomly selected sub sample of 15 non-respondents to determine why they did not respond. The main reason for non-response by the respondents was lack of time to fill up a nine pages (A4 paper size) questionnaire. All the non-respondents have given this reason. Non-respondents did not differ from respondents in terms of organizational demographics. Therefore, the actual replies received can be assumed to constitute the valid responses of the original sample.

3.5 Data Preparation

Proper data analysis requires effective data preparation and management. The length of the questionnaire, the number of completed surveys anticipated and data analysis software to be used, all had to consider in selecting a database-management system. A rational database-management program, Microsoft excel was chosen for this purpose. Survey responses were coded in the database. Both qualitative and non-quantitative, open-ended responses were recorded for possible future analysis. This also helped to clarify quantitative responses.

4 CLASSIFICATION OF DATA ANALYSIS

The analysis of the data from the survey has been divided in three parts, descriptive analysis, importance analysis and statistical analysis. The descriptive statistic used is to count the frequencies of the demographic information, calculate the proportion and present the results in tables. The objective of importance index analysis is to determine the numerical scores of each item. The statistical analysis is to determine the relationship between the variables and validate the performance measures/ factors. A proper analysis requires investigation of the descriptive characteristics of the organization and experts as well as statistical analysis of the factors. Descriptive analysis and important index analysis are presented in this paper.

4.1 Descriptive Analysis

Analysis of the data commenced with an investigation of the descriptive characteristics of the sample using Microsoft Excel. The descriptive analysis used is to

calculate the proportion, count the frequencies and present the results in tables from 122 different firms. Tables 2 summarize descriptive data of the respondents surveyed. The responses were classified based on region, in terms of regional distribution; the respondents were evenly divided among the four regions

Table 2: Regional Distribution of Respondents

Region	States Included	% Response
North	Punjab, Haryana, Himachal Pradesh, Uttar Pradesh	25%
South	Tamil Nadu, Karnataka, Kerala, Andhra Pradesh	35%
East	West Bengal, Bihar, Orissa	8%
West	Maharashtra, Gujrat, Madhya Pradesh, Rajasthan	32%

Table 3: Respondents by size of Organization

No. of Employees	% Response
Less than 100	0 %
101 to 500	10 %
501 to 1000	16 %
1001 to 5000	49 %
More than 5000	25 %

Table 4: Respondents by Annual Turnover of Firms

Annual Turnover (Rs in Crores)	% Response
50-100	6%
101-500	20%
501-1000	20%
1001-2000	16%
2001-5000	14%
5001-10000	15%
More than 10000	9%

Table 5: Respondents by Experience

Years of Experience	% Response
5-10 Years	9%
11-15 Years	30%
16-20 Years	31%
21-25 Years	20%
26-30 Years	6%
More Than 30 Years	4%

Table 6: Respondents by Designations

Designations	% Response
Manager / Engineers	31%
Sr. Managers / Sr. Superintendent / Sr. Engineers	36%
AGM / DGM / GM / Directors / Dy. Directors / Chief Engineer	33%

4.2 Importance Index Analysis

The numerical scores from the questionnaire provided a ngth of opinion of the effect of each item s of project. These are subsequently o relative importance index using the ula (adopted from Metri, 2001)

$$\frac{\sum_{i=1}^{5} a_i x_i}{5\sum_{i=1}^{5} x_i}$$

ex of item / variable:

$$\left(\frac{\sum_{i=1}^{5} a_i x_i}{5\sum_{i=1}^{5} x_i} \right)$$

The importance indices range from zero to 1. These indices reflect the relative importance of the factors listed in the questionnaire. The importance indices have been classified into five categories to reflect the respondent's rating as follows:

- Very Important: $0.8 < Ix \leq 1.0$
- Important: $0.6 < Ix \leq 0.8$
- Preferred: $0.4 < Ix \leq 0.6$
- Less Important: $0.2 < Ix \leq 0.4$
- Not Important: $0 < Ix \leq 0.2$

Table 7: Summary of Importance Index Analysis

S. No	Pillars of WCM	Very Important	Important	Preferred	Less Important	Not Important
1	Improvement	05	Nil	Nil	Nil	Nil

	of process/ equipment					
2	Ownership maintenance	Nil	04	01	Nil	Nil
3	Maintenance practices	02	06	Nil	Nil	Nil
4	Human resource development	Nil	05	01	Nil	Nil
5	Eliminative maintenance	Nil	04	01	Nil	Nil
6	Process quality maintenance	Nil	06	01	Nil	Nil
7	Support systems improvement	Nil	06	Nil	Nil	Nil
8	Safety, health and environmental system	Nil	05	01	Nil	Nil
9	Leadership and change management	Nil	05	02	Nil	Nil
10	Computer integrated maintenance management systems	02	07	01	Nil	Nil
11	Performance measures	Nil	04	05	Nil	Nil
	Total	09	52	13	00	00

Based on the classification, there are 09 variables that are rated 'Very Important' 52 that are rates as 'Important' and only 13 variables that are rated as 'preferred'. No variable is rated as either 'less important' or 'not important' category (see Table 7).

Table 8: Elements Ranking

Rank	Element No	Elements Description	Importance Index
1	E3	Equipment Classification and Standardization	0.890163934
2	E59	Support systems management	0.850819672
3	E4	Automation	0.845901639
4	E1	Continuous Improvement	0.842622951
5	E2	Process Reliability	0.840983607
6	E5	Tools and Techniques for improvement of equipment	0.839344262
7	E14	Corrective maintenance	0.813114754
8	E62	Work order planning and scheduling	0.813114754
9	E11	Preventive maintenance	0.806557377
10	E10	Tools and Techniques for ownership maintenance	0.793442623
11	E7	Operator Involvement	0.775409836
12	E9	Troubleshooting	0.772131148
13	E46	5S philosophy	0.76557377
14	E63	Performance measurements and reports	0.76557377
15	E60	equipment management	0.763934426
16	E64	outsourcing management	0.759016393
17	E61	Material management	0.755737705
18	E73	Effectiveness	0.752459016
19	E52	Participative management	0.752459016
20	E70	Flexibility	0.731147541
21	E16	Planned maintenance	0.731147541
22	E12	Predictive maintenance	0.72295082
23	E20	Manpower planning and Staffing	0.698360656
24	E13	Reliability centered maintenance	0.695081967
25	E6	Autonomous Inspection	0.691803279
26	E65	Financial control management	0.686885246
27	E17	Maintenance standardization and documentation	0.680327869
28	E37	common facilities	0.673770492
29	E15	Pro-active maintenance	0.672131148
30	E21	Cross-functional co-operation	0.66557377
31	E71	Morale	0.66557377
32	E18	Tools and techniques for maintenance systems	0.660655738

33	E58	Knowledge management	0.659016393
34	E23	Performance management	0.659016393
35	E30	Variation reduction in work processes	0.657377049
36	E39	Supply chain management	0.655737705
37	E28	Initial control for process	0.649180328
38	E27	Life cycle analysis	0.645901639
39	E31	Quality assurance	0.645901639
40	E42	Tools and techniques for support system improvement	0.644262295
41	E22	Incentive plans and benefits	0.640983607
42	E72	Productivity	0.640983607
43	E24	Enhancing employee relations	0.639344262
44	E55	Management support	0.637704918
45	E36	Tools and techniques for process quality maintenance	0.632786885
46	E25	Research and development of new process	0.631147541
47	E35	Elimination of forced deterioration	0.629508197
48	E54	Organization structure	0.629508197
49	E40	Work flow management	0.629508197
50	E38	Contractor management	0.627868852
51	E47	Occupational health systems	0.62295082
52	E41	Spares management	0.621311475
53	E26	Failure evaluation	0.619672131
54	E48	Tools and techniques for safety, health and environmental systems	0.614754098
55	E57	Resource management	0.613114754
56	E33	Standardization of 3Ms	0.613114754
57	E53	Empowerment	0.609836066
58	E44	Environmental systems	0.609836066
59	E34	Living Programme	0.608196721
60	E51	Cost distribution and financial control	0.604918033
61	E45	Safety systems	0.603278689
62	E43	Regulatory compliance	0.598360656
63	E29	Tools and techniques for eliminative maintenance	0.596721311
64	E74	Competitive advantages	0.595081967
65	E32	Measurement systems	0.595081967
66	E69	Safety and work environment	0.585245902
67	E67	Cost	0.581967213
68	E56	Maintenance planning and scheduling	0.580327869
69	E66	Quality	0.578688525
70	E8	Initial Cleanup	0.57704918
71	E49	Organization culture	0.57704918
72	E68	Delivery	0.572131148
73	E50	Maintenance strategy and policy deployment	0.567213115
74	E19	Training and development	0.567213115

5 CONCLUSION

Out of 504 companies, 122 valid responses were received. The overall response rate was 24.2%. Based on the classification, there are 09 variables that are rated 'Very Important' 52 that are rates as 'Important' and only 13 variables that are rated as 'preferred'. No variable is rated as either 'less important' or 'not important' category and the Variables / Items according to the ranking are listed in Table 8. Items with same importance index are ranked according to their appearance in the data sheet. Respondent has given very much importance to the Equipment Classification and Standardization (E3) i.e. 0.890 and less important item is training and development (E19) i.e. 0.5672. Ideally, all the variables would be included for the study and further analysis purposes. The frequency of favorable response to elements indicates that a representative majority of industry professionals have recognized the concept and it's potential.

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