# Application of AHP in Measuring and Comparing Quality of Manufacturing Industries

**Mohit Singh, Dr. I.A. Khan, and Dr. Sandeep Grover**

*Abstract*— **Quality has become a prerequisite for success in global market. Urge for quality and excellence is not new. Customers have always desired quality goods. For the last two decades organizations have been anticipating profitability, quality and customer satisfaction through various techniques. Quality has become a strategic priority for business around the world because of its proven significance for achieving and maintaining competitive advantage. With the organizations spending resources for adoption and implementation of Quality, it becomes necessary to assess their performance. The present work provides a methodology for comparison and selection of industries based on their Quality performance using Analytic hierarchy Process (AHP). The AHP model covers broad areas of quality, commitment and satisfaction. The model considers criteria of human resource; material, machine & methodology; Planning the organization, Organizational culture; Supplier and customer; and Inspection strategies. The different quality level at system and subsystem levels are identified and prioritized based on literature and body of knowledge at different levels using pairwise comparison thus assigning them global weightage. To find out the Local weightage and rating of the factors a survey has been conducted in around 146 manufacturing Industries. The present methodology is dynamic in nature and takes into consideration Quality factors along with their predefined weightage before arriving at a selection.**

***Keywords***— AHP, Critical Factors, Quality and Pair-wise Comparison

## I. INTRODUCTION

As the competition is increasing day by day, new industries introduces in the market with newer techniques and special offers, to stay in the market and earn the customers. With this increased competition, the survival of industry now becomes awkward, so to maintain their stake in the market and earn more and more profits, the Industries becomes least concern about the quality level of the product and for this reason the quality of products is deteriorating day by day. The Industry just wants to earn more and more profits at low cost because every customer needs the product at lower price due to competitive environment and due to this the quality level of the products deteriorating. So to get good quality of the product this technique of evaluation of manufacturing industry is very useful. To improve the quality of the product one has to consider several quality factors like man power, vendor's performance, materials etc. In this paper the author critically examined the factors and co – factors which affect the product quality directly or indirectly. This paper presents the main results of a recent study that investigated the critical success factors affecting the Quality level of manufacturing Industries in Northern India. In Northern India the manufacturing industries had undergone fast pace economic developments with significant efforts.

The study attempted to identify the critical factors and co - factors to quantify the manufacturing industries using the analytic hierarchy process (AHP) approach. A generic hierarchy model was elaborated to help prioritize these factors and formulate strategies for quantification of quality level in manufacturing industries.

Manuscript submitted on May 27, 2011.

Mohit Singh is a Research Scholar, Department of Mechanical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi, India, email: sinmohit@gmail.com.

Dr. I. A. Khan is a Professor, Department of Mechanical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi, India.

Dr. Sandeep Grover is a Professor& Head, Department of Mechanical Engineering, YMCA University of Science & Technology, Faridabad (HR), India.

## II. LITERATURE REVIEW

Quality competence is the ability that the organization acquires sustainable competitive predominance and realizes sustainable development in virtue of excellent quality [1]. A company must focus on both their immediate customers and those next in the chain [2]. So creating a win-win situation is a basic requirement for each supplier and manufacturer. And creating triple wins produces expansion for the entire industry [3]. In today's international business environment, quality cannot be underestimated or overlooked by any firm, regardless of its size or assets [4]. Researchers suggests that managing well supplier involvement can lead to better supplier performance, improved manufacturing, and product and process advancements that in turn enhance customer satisfaction and firm performance [5]. Loyalty of customers is a function of satisfaction, and loyal customers: spend more on your products and services; encourage others to buy from you; and, believe that what they buy from you is worth what they pay for it [6]. Customer satisfaction is considered to be one of the most important competitive factors for the future. Some consequences of customer satisfaction are: improvement of the firm's reputation and image; reduction of customer turnover; increased attention to customer needs in TQM planning; reduction of marketing costs and, vice versa, lower transaction costs; reduction of costs related to product/service failures;

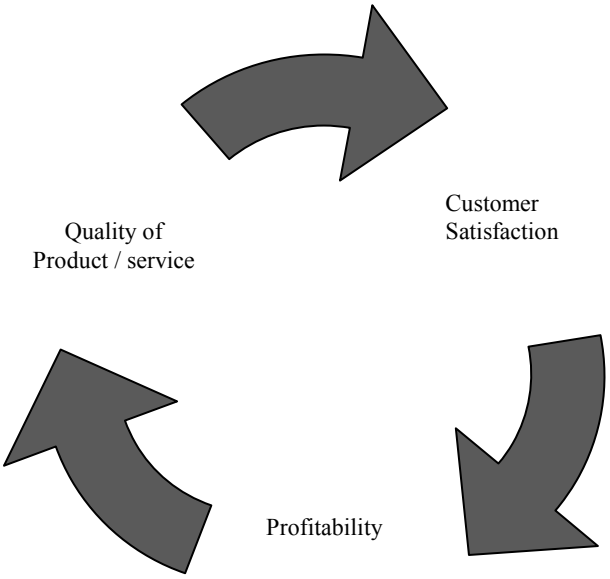


Fig. 1. Dependence between quality, satisfaction and profitability [11]

and, lastly, increased satisfaction among personnel and greater stability of the workforce [7]. In relation to the awards, customer satisfaction is seen as one component of the quality system, even though, as in the Baldrige Award, it is sometimes the most important one [8]. In the European Quality Award customer satisfaction is one out of three satisfaction results, the others being employee satisfaction and society satisfaction [9]. In fact, techniques and tools are vital to support and develop the quality improvement process [10].

The definition of quality is satisfaction of needs or requirements. So it is very clear that the Quality, customer satisfaction and Profitability are interdependent. When the customer becomes satisfy from the quality of the product then only they will buy the product. If the product does not meet the customer requirement then definitely the customer will not buy the product or services. And once the customer becomes satisfy one can earn good profits from the customer.

### *A. Critical Factors*

There are six critical factors for implementation of AHP technique namely:

- Human Resource
- Material, Machine and Methodology;
- Planning;
- Organizational Culture;
- Supplier and Customer;
- Inspection

Table 1: Factors & Co-factors affecting quality of manufacturing Industry

| Factors | Co -Factors |
|---|---|
| **Human Resource** | Manpower Planning, Employee Attitude, Employee Motivation, Adequate Supervision, Education & Training |
| **Material, Machine and Methodology** | Effective Manufacturing Methodology, Uninterrupted Flow of Material, Tools used, Adequate Process capability, Safety Requirements, Transportation & Storage |
| **Planning** | Financial Planning & Analysis, Plant Location & Layout, Competition in the Market, Facilities Provided to Employees |
| **Organizational Culture** | Working Conditions, Unhealthy relationships with outside partners, Harmonious relationship within the Industry, Comprehension of management towards quality |
| **Supplier and Customer** | Capacity verification of vendors, Vendor vendee relationships, Surveillance of quality at vendor's work, Performance feedback on reliability |
| **Inspection** | Inspection Procedures, Procurement of special test equipment, Process Surveillance and Inspection |

#### *1). Human Resource*

This factor involves management of Human resource inside or outside the industry. It plays a vital role in management of quality in any manufacturing industry. Deming (1986) stresses the human aspects in his 14-points for quality improvement. Other quality experts (Crosby, 1979 [13]; Juran, 1986 [14]; Steeples, 1992 [15]) also underline the roles of human resource development to maximize people's ability.

The co-factors of this human resource are: man power planning, employee attitude, human relations, employee motivation, and adequate supervision.

- In man power planning the employee are segregated according to their skills and then assigned related assignments to them to get the best output from them.
- The attitude of employee must be qualitative then only they can produce quality goods.
- The employee must be motivated enough so that they will work for their organization full heartily because a demotivated employee always get frustrated and will not be able to work satisfactorily. A employee can be motivated by their salary, bonus, promotions and increments, they should also be recognized time to time through awards etc for their best work and achievements.
- The employee must be supervised effectively for proper workdone and results.
- The employees should be trained and educated properly before assigning them any new job or assignments so that

the system should work effectively because an untrained worker may lead to accident, wastage and scrap will increase, so to reduce them the training of employees are necessary.

### *2). Material, Machine and Methodology*

The material, machine and methodology are the three m's which affect the quality of manufacturing strongly. The co-factors are: Effective manufacturing methodology, uninterrupted flow of material, Tools used, adequate process capability, Safety requirements, Transportation and storage.

- The manufacturing methodology should be of that type so that only good quality of jobs will produce at low cost and time, with low wastage and scrap. The machines used should be properly maintained time to time, any improper maintenance will produce vibrations, affecting the functioning of machines, breakdowns will increase and ultimately the product of quality will deteriorate.
- Poor quality of materials is the most common reason for the failure of the products [16]. The material should also be of that type so that it will not produce any side effect to other man, machine and material. Sometimes the poor quality of material is available at concessional price which affects the quality level badly. So always buy only good quality of raw material. The material must be available readily so that an uninterrupted flow of material is maintained; any interruption in the flow of material may lead to sudden break of production line which affects the production quality and quantity badly. To get the uninterrupted flow of material always choose well reputed vendor, who will supply good quality material within the time.
- The tools and other attachment used for production with the machine must be of good quality and handled properly because sometimes due to mishandling of tools they will get damage.
- The process capability of the system should be good otherwise the whole system will collapse.
- One should take care about the safety requirements because any carelessness may lead to severe consequences like accidents, fire etc.
- The transportation and storage is also an important factor, during transportation of material or products, one should take care that they should not break or damage during transportation and will reach to their destination on time. The material and products should be stored in a way that they should not spoil by any means like seepage, moisture, temperature changes or any other reason.

### *3). Planning*

Planning is the first step in the process of management. Planning is deciding in advance what to do, where to do and by whom to do. Basically, planning is deciding the future course of action in present. Thus, planning bridges the gap between present and future. The co-factors of planning are: financial planning and analysis, plant location and layout, competition in the market, facilities provided to employees, effective feedback of customer.

- The financial planning and analysis meant for forecasting the expenditure as regards to production cost, plant utilization, selling and distribution, purchases, etc. On behalf of this factor any organization can plan their future accordingly and investments in the organization.
- The performance of an Industry is considerably affected by its location and layout. Unscientific and Unplanned Location and layout produce a very harmful effect on the performance of manufacturing unit. It includes all major factors like travel time, cost of production, selling price etc.
- One should consider the competition present in the market and design their product and cost accordingly.
- Adequate facilities should be provided to the employees so the working environment remains good like proper fans, lighting, drinking water etc. All these things keep the workers fresh and then they can work efficiently.

### *4). Organizational Culture*

Organizational culture meant for providing best environment within the organization for the efficient, systematic, positive and coordinated applications of available resources. The co-factors of organizational culture are: Working conditions, Unhealthy relationships with outside partners, Interdepartmental relationships, Harmonious relationships within the Industry, Comprehension of management towards quality.

- Working conditions meant here for physical environment which directly related to the employees like Noise of the machines, heat dissipation, hard water etc, such type of elements should be avoided to get the best working environment.
- The relationships of the Industry people with others outside the Industry should be good which directly or indirectly maintain their reputation or business in the market. Firms producing high-quality products give far greater attention to developing partnerships with exceptional suppliers than on reducing piece price [17].
- Harmonious relationship with in the Industry deals with the men and their behavior. It deals with the personnel required to administrate, manage and carryout the functions of the system. Human relations, as a corporate philosophy of administrative vitality and action, play a significant role in maintaining the quality of the Industry.
- In order to implement quality policies within the industry, the management should create an organizational environment that focuses on continuous improvement. Their commitment promotes the creation of clear and visible quality values, along with a management system to guide all activities of the company towards quality excellence.

### *5). Supplier and Customer*

Supplier and customer are the two major factors which plays a significant role in quality management of any industry. Managing well supplier involvement can lead to better supplier performance, improved manufacturing, and product and process advancements that in turn enhance customer satisfaction and firm performance. (Epatko, 1994 [18]; Schilling and Hill, 1998 [19]; Vonderembse and Tracey, 1999 [20]; Shin et al., 2000 [21]). The co-factors are: capacity verification of vendors; vendor vendee relationships; Suervillance of quality at vendor's place; performance feedback on reliability.

- The Industry People should verify the capacity of the vendors that whether the vendor is able to supply the required product in required quantity or quality or not. Suppose if the vendor is not able to supply the right quantity or quality of material then the manufacturing process will badly affected and the quality will deteriorate.
- The relationships between vendor and vendee should always good. The Industry people have the important responsibility of selecting suppliers within the framework of achieving system-wide goals as opposed to minimizing piece price (Bregman, 1995 [22]; Mason, 1996 [23]; Krause, 1997 [24]; Roos, 1998 [25]; Degraeve and Roodhooft, 1999 [26]). They have relationship managers; facilitating decision making by bringing together the pertinent parties internal and external to the organization (Cooper and Ellram, 1993 [27]).
- The Industry must sent some Inspectors at the vendors place to check that whether vendor making their product as per requirements or not. If not then they can stop or correct them in between which prevent wastage of material and time.
- The feedback of the customer plays a significant role in determining the quality of the product, as per the feedback of the customer the Industry should made amendments in their product to reach the quality level according to the customer.

### *6). Inspection*

Inspection is the part of quality control. Inspection is the act of checking materials, parts, components or products at various stages in manufacturing and sorting out the faulty or defective items from good items. The co-factors are: Inspection procedures; procurement of special test equipment; Process surveillance and Inspection.

- Inspection procedure is concerned with quality of past production to judge conformance with specifications and sorting out defective items from good items. So the Inspection procedures must be so accurate that no any defective item gets through.
- Inspection must be done through proper test equipment. For correct measurement and testing, right instrument should be used. Sometimes in industry, they do not used the right instrument for any special measurement due to high cost of instrument. They try to work with below standard or cheap instrument to save the cost which lead to wrong measurement and quality level goes down.
- Inspection is not always the final activity of any product. It should be done in between also so that if anything goes wrong in the process, it can be protected in between to prevent the wastage and scrap.

## III. METHODOLOGY

The Analytic Hierarchy Process (AHP) is a system technique used for dealing with problems which involve the consideration of multiple criteria simultaneously. AHP is the technique that can combine qualitative and quantitative factors for prioritizing, ranking and evaluating alternatives. The first step in AHP is to develop a hierarchical representation of a problem. At the top of the hierarchy is the overall objective and the decision alternatives are at the bottom. Between the top and bottom levels are the relevant attributes of the decision problem for comparing alternatives.

The number of levels in the hierarchy depends on the complexity of the problem and the decision maker's model of the problem hierarchy. Once the hierarchical representation is identified, one generates relational data for comparing the alternatives. Then one determines the relative priority of each attribute using the comparisons.

Finally, one calculates the priorities or weights of the lowest level alternatives relative to the top-most objective. The AHP uses paired comparisons to develop the prioritization. This simple, intuitive approach of comparing alternatives limits the cognitive demand on the decision maker and provides a means for checking the consistency of the comparisons.

In order to investigate the managerial views on the critical factors that will affect the Quality in manufacturing Industry, the authors have conducted a survey in manufacturing Industry of Northern India using the AHP approach. There are four manufacturing Industries are chosen for the application of AHP technique:

The research has divided into four parts:

(1) Structuring the problem and developing the AHP model;

(2) Collecting data from survey;

(3) Determining the normalized priority weights of individual factors and co-factors.

(4) Derive solution

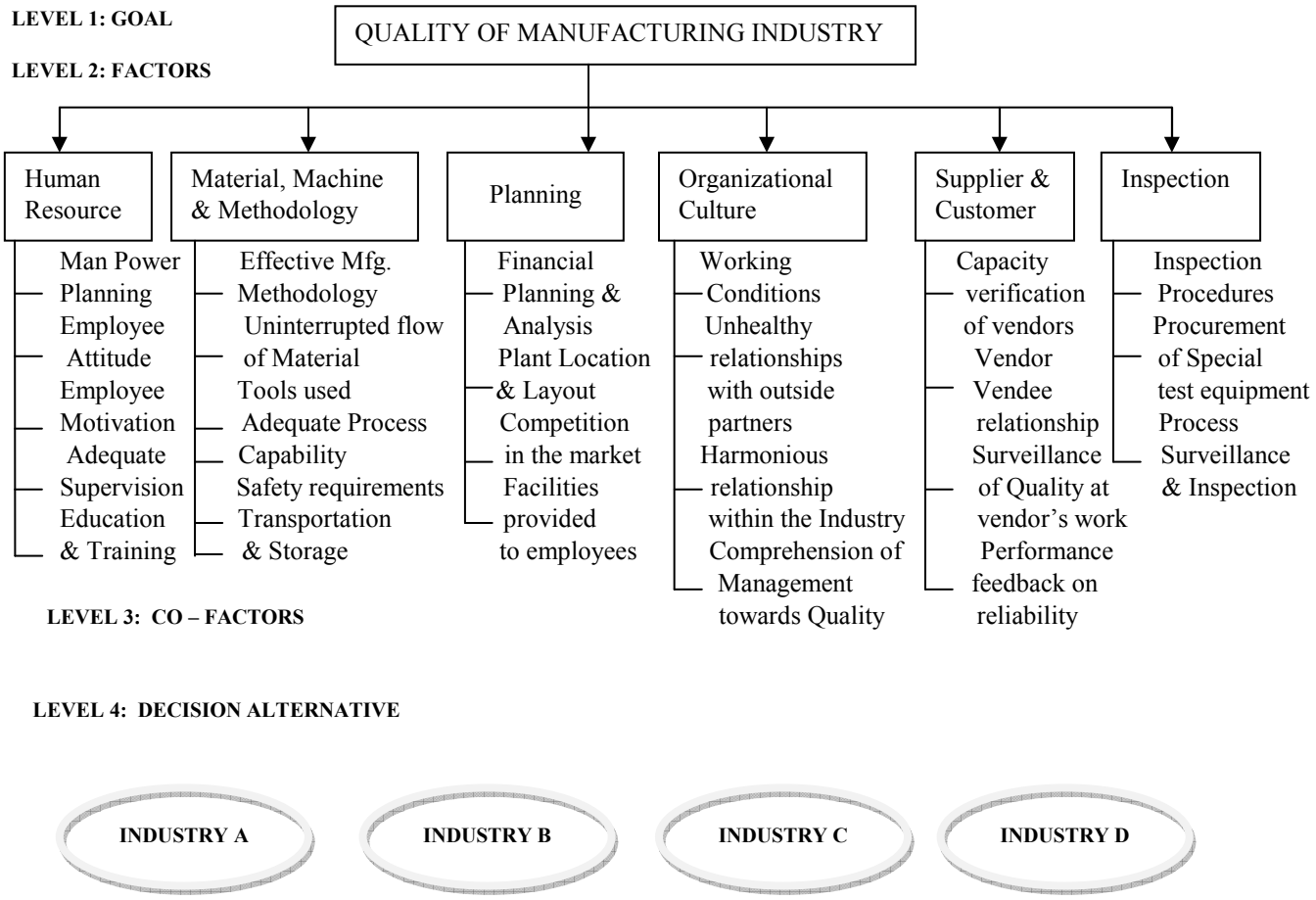


Fig.2. Hierarchical model for comparing quality of manufacturing Industries

According to the critical factors the problem is converted into a model tree of hierarchical structure.

The model has four levels as shown in Fig. 2.

Level 1: Declares the goal of the problem

Level 2: Critical factors,

Level 3: Co-factors of the critical factors

Level 4: Result

To determine the local weights and rating we have conducted a survey in 257 manufacturing industries of northern India and out of 257 Industries we received the proper information from 146 manufacturing industries. Although it is difficult to analyze and quantify the intangibles, however for the purpose of application of methodology the data has been taken after this precise survey and discussions with Industry personals, academicians and complied in Table 2 and the local weights of each factor each shown by the chart. Liberatore [28] suggested a five point rating scale of Outstanding (O), Good (G), and Average (A), Fair (F), Poor (P).This scale is adopted and priority weights of these scales can be determined using pairwise comparisons. Using pairwise comparison judgment matrix is generated. Liberatore found priority weights of outstanding, good, fair, average, and poor as 0.513, 0.261, 0.129, 0.063, and 0.034, respectively.

Table 2: Composite priority weights for performance evaluation

| Factors | Local Weights | Criteria | Local Weights | Global Weights |
|---|---|---|---|---|
| **Human Resource** | 0.323 | Man Power Planning (MPP) | 0.606 | 0.196 |
| | | Employee Attitude (EA) | 0.222 | 0.072 |
| | | Employee Motivation (EM) | 0.070 | 0.023 |
| | | Adequate Supervision (AS) | 0.073 | 0.024 |
| | | Education and Training (ET) | 0.029 | 0.009 |
| **Material, Machine & Methodology** | 0.219 | Effective Manufacturing Methodology (EMT) | 0.507 | 0.111 |
| | | Uninterrupted flow of material (UFM) | 0.221 | 0.048 |
| | | Tools used (TU) | 0.106 | 0.023 |
| | | Adequate Process Capability (APC) | 0.114 | 0.025 |
| | | Safety requirements (SR) | 0.067 | 0.015 |
| | | Transportation and Storage (TS) | 0.150 | 0.033 |
| **Planning** | 0.210 | Financial Planning and Analysis (FPA) | 0.290 | 0.061 |
| | | Plant Location and Plant Layout (PPL) | 0.324 | 0.068 |
| | | Competition in the market (CM) | 0.256 | 0.054 |
| | | Facilities Provided to employees (FPE) | 0.130 | 0.027 |
| **Organizational Culture** | 0.038 | Environmental Conditions (EC) | 0.218 | 0.008 |
| | | Unhealthy relationships with outside partners (UROP) | 0.328 | 0.012 |
| | | Harmonious relationship within the industry (HRI) | 0.223 | 0.008 |
| | | Comprehension of management towards quality (CMQ) | 0.231 | 0.009 |
| **Supplier and Customer** | 0.058 | Capacity verification of vendors (CVV) | 0.513 | 0.029 |
| | | Vendor-vender relationships (VVR) | 0.235 | 0.014 |
| | | Surveillance of quality at vendor's work (SQVW) | 0.153 | 0.009 |
| | | Performance feedback on reliability (PFR) | 0.099 | 0.006 |
| **Inspection** | 0.152 | Inspection Procedures (IP) | 0.365 | 0.059 |
| | | Procurement of special Test equipment (PSTE) | 0.367 | 0.056 |
| | | Process Surveillance and Inspection (PSI) | 0.268 | 0.041 |
| **Total** | 1.000 | | | 1.000 |

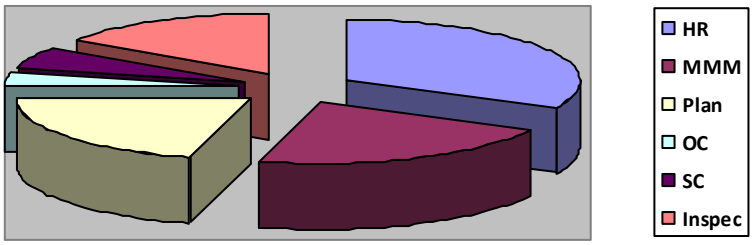


Fig. 3. Local weights of different factors

The rating and weights of all criteria are shown in Table 3. Multiplying the global priority weights and rating and subsequently adding the resulting values we can find the score of different Industries. Based on global priority weights of the four Industries shown in Table 3, Industry B has the highest weight. Therefore Industry C stands high on basis of evaluation.

Table 3: Application of AHP Model to Evaluate manufacturing Industries

| Factors | Global Weight | INDUSTRY A | | INDUSTRY B | | INDUSTRY C | | INDUSTRY D | |
|---|---|---|---|---|---|---|---|---|---|
| | | Rating | Score * GW | Rating | Score * GW | Rating | Score * GW | Rating | Score * GW |
| MPP | 0.196 | O | 0.100548 | G | 0.051156 | G | 0.051156 | F | 0.012348 |
| EA | 0.072 | F | 0.004536 | F | 0.004536 | G | 0.018792 | G | 0.018792 |
| EM | 0.023 | F | 0.001449 | O | 0.011799 | G | 0.006003 | G | 0.006003 |
| AS | 0.024 | A | 0.003096 | F | 0.001512 | F | 0.001512 | A | 0.003096 |
| ET | 0.009 | G | 0.002349 | F | 0.000567 | G | 0.002349 | P | 0.000306 |
| EMT | 0.075 | P | 0.00255 | G | 0.019575 | A | 0.009675 | P | 0.00255 |
| UFM | 0.048 | A | 0.006192 | A | 0.006192 | A | 0.006192 | A | 0.006192 |
| TU | 0.023 | P | 0.000782 | A | 0.002967 | F | 0.001449 | P | 0.000782 |
| APC | 0.025 | P | 0.00085 | F | 0.001575 | A | 0.003225 | P | 0.00085 |
| SR | 0.015 | O | 0.007695 | A | 0.001935 | P | 0.00051 | A | 0.001935 |
| TS | 0.033 | G | 0.008613 | G | 0.008613 | G | 0.008613 | F | 0.002079 |
| FPA | 0.061 | G | 0.015921 | O | 0.031293 | F | 0.003843 | P | 0.002074 |
| PPL | 0.068 | A | 0.008772 | A | 0.008772 | G | 0.017748 | P | 0.002312 |
| CM | 0.054 | F | 0.003402 | P | 0.001836 | F | 0.003402 | P | 0.001836 |
| FPE | 0.027 | F | 0.001701 | P | 0.000918 | G | 0.007047 | A | 0.003483 |
| EC | 0.008 | F | 0.000504 | F | 0.000504 | G | 0.002088 | F | 0.000504 |
| UROP | 0.012 | F | 0.000756 | G | 0.003132 | G | 0.003132 | F | 0.000756 |
| HRI | 0.008 | A | 0.001032 | F | 0.000504 | F | 0.000504 | A | 0.001032 |
| CMQ | 0.009 | G | 0.002349 | A | 0.001161 | F | 0.000567 | F | 0.000567 |
| CVV | 0.029 | P | 0.000986 | P | 0.000986 | O | 0.14877 | F | 0.001827 |
| VVR | 0.014 | O | 0.007182 | G | 0.003654 | O | 0.007182 | G | 0.003654 |
| SQVW | 0.009 | A | 0.001161 | G | 0.002349 | F | 0.000567 | F | 0.000567 |
| PFR | 0.006 | G | 0.001566 | A | 0.000774 | G | 0.001566 | F | 0.000378 |
| IP | 0.059 | G | 0.015399 | F | 0.003717 | O | 0.030267 | G | 0.015399 |
| PSTE | 0.056 | F | 0.003528 | A | 0.007224 | A | 0.007224 | G | 0.014616 |
| PSI | 0.041 | A | 0.005289 | A | 0.005289 | F | 0.002583 | F | 0.002583 |
| **Total** | **0.208208** | | **0.18254** | | **0.345966** | | **0.106521** | | |

## IV. RESULT AND ANALYSIS

In today's economy, the survival of industries depends greatly on its ability to provide superior service which generates customer satisfaction. Customer satisfaction cannot be guaranteed unless the industry establishes its service performance measures and compares its performance against that of the service leader using such measures. This paper proposed the use of AHP as powerful tools for evaluating the manufacturing industry competitiveness. In this work factors affecting performance of Industries are identified and analyzed systematically using Analytical Hierarchy Approach (AHP). The technique has been used by different authors in various fields for selection among alternatives. Application of this technique helps in analysis of various criteria and sub criteria leading to selection, comparison and ranking of Industries based on performance. This will further help in self appraisal and improvement. The organizations can further identify the gaps among the factors and can make efforts to improve thereupon. However, the scores and weight-ages may vary depending upon type of organization, size of organization and the geographical location. In this paper the industries A, B, C and D scored 0.208208, 0.18254, 0.3459 66 and 0.106521 points respectively. The results illustrate that Industry C has been capable in maintaining the quality better than other industries and industry D has been the worst.

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