

# Validating Green Manufacturing (GM) Framework for Sustainable Development in an Indian Steel Industry

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**Abstract** Green manufacturing (GM) is a term used to describe manufacturing practices that do not harm the environment during any part of the manufacturing process. It emphasizes the use of processes that do not pollute the environment or harm consumers, employees, or other members of the community. GM stresses on reducing parts, rationalizing materials, and reusing components, to help make products more efficient to build. This paper presents the details of a case study. It highlights the road map of the company for achieving performance improvement through GM implementation and its impact on organizational performance. It also points out strengths and weaknesses of GM implementation practices and overall performance using developed research instrument. The case study helps in evaluating the company's GM implementation and overall business performance. To do so, research instrument was administered amongst forty one employees in the companies respectively and their responses were analyzed. Using the data obtained from a survey of industries in India, the identified factors were subjected to appropriate statistical tests to establish reliable and valid model. Statistical computing package SPSS 17.0 for Windows was used for reliability and validity analysis. The validated instrument of GM factors developed here may be used by manufacturing organizations to priorities their management efforts to assess and implement GM. The validated results are in Indian context; however, the instrument developed can be used in global context.

**Keywords** Green Manufacturing, Critical Success Factors, Reliability Analysis, Factor Analysis

## 1. Introduction

Green Manufacturing (GM) is a method for manufacturing that minimizes waste and pollution. It slows the depletion of natural resources as well as lowering the extensive amounts of trash that enter landfills. Its emphasis is on reducing parts,

rationalizing materials, and reusing components, to help make products more efficient to build. GM involves not just the use of environmental design of products, use of environmental friendly raw materials, but also eco-friendly packing, distribution, and disposal or reuse after the lifetime of the product. Green manufacturing is a term used to describe manufacturing practices that do not harm the environment during any phase of the manufacturing. It emphasizes the use of processes that do not pollute the environment or harm consumers, employees, or other members of the community. Green manufacturing addresses a number of manufacturing matters, including 4R's (Reduce, Reuse, Recycle and Remanufacturing), conservation, waste management, water supply, environmental protection, regulatory compliance, pollution control, and a variety of related issue.

### *Green Manufacturing Practices Indian scenario*

Indian Companies are feeling the pressure to go green, as many of their Western counterparts are building environmental sustainability into their business practices. For example, Wal-Mart, which annually imports over \$3 billion in goods from Indian suppliers, recently asked them to adopt green practices or risk losing the retail giant as a customer. For Indian companies, there are other compelling reasons to develop GM practices. As leading companies know, going green, if done right, helps companies bolster their fortunes. Few of the manufacturing firms had ensured to comply with the RoHs directive. Here is a list of the Top Clean Technology / Alternative Energy/ GM practicing Companies in India according to Verdurous India Index.

1SuzlonEnergy, 2 ITC Limited, 3Tata Metaliks Limited (TML), 4TamilNadu Newsprint and Papers Limited(TNPL), 5Wipro Technologies, 6HCLTechnologies, 7Oil and Natural Gas Company (ONGC) and the list continue....

To achieve real financial benefits, Indian companies, like those elsewhere, need to follow certain key practices. Above all, they must commit to a green philosophy and incorporate GM practices into their product lifecycle and supply chain operations. Ramakrishna (2006) claims that major industries in India focusing on reducing energy consumption, water

consumption, hazardous substances, waste ,emission also Green purchasing network is spreading its wings in India .According to Mukherjee & Kathuria(2006) efforts are taken by leading firms for Prevention of potential hazards to the environment as well as getting ISO 14001 certification. Few of the manufacturing firms had ensured to comply with the RoHs (reduction of hazardous substance) directive.Economic growth plays a crucial role for overall society development. However, economic development and environmental sustainability are not supplementary to each other.

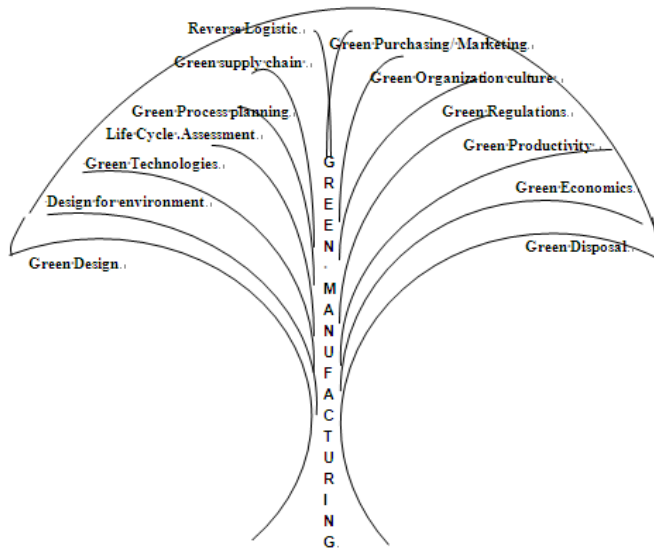


Figure 1. Green Manufacturing Tree

## 2. Review of Literature

Critical success factors (CSF's) are the vital input factors that will drive a good GM system. Different authors have attempted to investigate the CSFs in GM with differing purposes and objectives. Critical factors should be interpreted as those circumstances or practices which already exist, or those that need to be developed in ensuring the success of GM implementation. Performance measures are deliverables or output of a GM system. Improving organizational performance is a goal of every organization. Organizational performance is the final result of running a business. It can reveal the effects of doing business, show the competitive capability of the firm in the market place and its financial status. Organizational performance is a good indicator to test the effects of improvement practices and of companies' efforts in pursuing performance measures. An objective of this study is to evaluate the factors which have positive impact on the organizational performance indicators in Indian manufacturing companies. The requirements of GM critical success factors and performance measures proposed by various authors are briefly described below.

According to Gutowski et al. (2005) [6] Motivating factors for GM are regulatory mandates, economic advantage, reduced waste treatment and disposal costs,

conservation of energy, water, materials, product take-back system, supply chain requirements, corporate image, and employee satisfaction.

Deanna J. Richards(1994) [3] stresses on various CSFs of environmental conscious manufacturing viz. meeting customers needs, environmental tradeoffs, reuse, recycle LCA, green design, disposal etc.

According to Richard Florida et.al (2000) [5] Factors play a key role in the adoption of environmental innovations, referred to as GM practices, organizational resources, organizational innovativeness, and organizational monitoring systems .The research also explored the interplay of organizational factors and spatial or geographic factors (such as proximity to customers and suppliers) in the adoption of ECM practices.

Devashish Pujari (2003)[12] includes environmental benchmarking and measurement, effective groundwork, cross-functional coordination, environmental database, supplier involvement, environmental policy/ legitimation. Three other factors emerging with relatively low variance were top management support and involvement, product experimentation, and environmental coordinator.

M.A.Rehman and R.L. Shrivastava(2011) [10] identified nineteen measures of GM includes Top management commitment, Need and role of employee team responsible for GM ,Green process/practices ,Green design ,Green purchasing/marketing ,Green packaging, Green transportation ,Green supply chain management ,GSCM ,Reverse logistic ,Reduce /remanufacture/recycle (3R) etc.

Jaideep Motwani (2001) [11] identified seven critical factors and more than 45 performance measures of TQM. Including Top management commitment; quality measurement and benchmarking; process management, product design, employee training and empowerment, supplier quality management, customer involvement and satisfaction.

Pius Achanga, et.al(2006) [14] identified Several critical factors that determine the success of implementing the concept of lean manufacturing within SMEs that includes leadership, management, finance organisational culture and skills and expertise.

Jiju Antony et.al (2002) [7] Identify CSFs of TQM in hongkong industries .through literature review identifies 7 factors and 38 elements including management commitment, customer satisfaction, continuous improvement etc.

Wee & Quazi (2005)[13] recommended specific performance measures by listing seven factors identified as the key elements of Green manufacturing through reliability and validity analyses -top management commitment to environmental management, total involvement of employees, training green product/process design, supplier management, measurement, and information management .According to Wee and Quazi, there is a need to focus on environmental issues for improving the performance of organizations

According to Cote and Richardson (2009) [2] the corporate drivers for green manufacturing include public

opinion, shareholder value, cost reductions, joining industry leaders and complying with environmental management regulations.

According to Lele .S (2009) [9] there are many drivers which are expanding the boundaries for green manufacturing. A growing number of executives today feel that going green will help them to compete more effectively in the marketplace in the long term. In summary the major drivers can be grouped into three key areas competitiveness, corporate social responsibility, and legislation.

According to Gutowski et al. (2005)[6] Motivating factors for GM are regulatory mandates, economic advantage, reduced waste treatment and disposal costs, conservation of energy, water, materials, product take-back system, supply chain requirements, corporate image, and employee satisfaction.

Digalwar and Sangwan(2007)[4] identified sixteen performance measures of World Class Manufacturing and their 89 variables have been developed. According to them environmental health measures need to be focused

Azzone &Noci(1998) [1] ,identified various PM for the deployment of GM strategies includes, change in production planning, procurement polices, cleaner technologies, Involvement of employees and Top managerial in design and development phase ,recycling base activities,

EOL,LCA, Takeback, economic value creation monitoring physical indices( waste water, air emission, solid waste & energy consumption)

Kit Fai Pun (2006) [8] identifies 15 environmental responsible operations (ERO) /factors under three groupings, namely policy, product/process, and performance evaluation.

Using a thorough synthesis of the Green manufacturing literature, twelve critical success factors and six performance measures of Green manufacturing practices and their variables have been developed. Using the data obtained from a survey of manufacturing industries in India, the identified factors were subjected to appropriate statistical tests to establish reliable and valid GM Model. Statistical computing package SPSS 17.0 for Windows was used for reliability and validity analysis.

### 3. GM Framework

Depending upon the critical success factors and performance measure a validated instrument of GM factors is developed .Based on the information provided by the respondent and the analysis of survey data about GM implementation for manufacturing companies in India, a GM frame work is developed. Statistical methods such as descriptive statistics, factor analysis, correlation analysis, regression analysis and hypotheses testing were used in the analysis. Table1 shows the strong and weak relationship between the various GM implementation factors and the Performance measures.

**Table 1.** GM Factors and Organization performance measures relationships

| Sr. No | GM performance measure                    | Relationship with Critical factors of GM   |  |
|--------|---|--|--|
|        |   | Strong   | Weak   |
| 1      | <b>Financial and Manpower Performance</b> | Green Standard Adaptation, Organizational Capabilities, Implementing RL, Technology Innovation, Green purchasing & marketing, Process management, Green Design Initiatives | Suppliers management, GM planning:, Top management commitment ,Customers Focus<br>Green Disposal Initiatives,  |
| 2      | <b>Operational Performance</b>            | Green purchasing & marketing , Implementing RL , Green Standard Adaptation , Green Design Initiatives ,  | Organizational Capabilities ,Suppliers management, Technology Innovation, GM planning:, Top management commitment ,Customers Focus ,Green Disposal Initiatives, Process management         |
| 3      | <b>Competitive advantages</b>             | Green purchasing & marketing , Implementing RL , Standard Adaptation , Green Design Initiatives , Process management , Technology Innovation ,                             | Organizational Capabilities ,Suppliers management, GM planning ,Top management commitment ,Customers Focus<br>Green Disposal Initiatives,,   |
| 4      | <b>Continuous Improvement</b>             | Green Standard Adaptation ,Green Design Initiatives ,Implementing RL ,Top management commitment , Process management , GM planning: ,                                      | Organizational Capabilities ,Suppliers management, Technology Innovation,, Green purchasing & marketing ,Customers Focus Green Disposal Initiatives,                                       |
| 5      | <b>Stakeholders Enrichment</b>            | Green Standard Adaptation, Implementing RL ,Green Design Initiatives , Suppliers management ,  | Organizational Capabilities ,Technology Innovation, GM planning:, Green purchasing & marketing ,Top management commitment ,Customers Focus, Green Disposal Initiatives, Process management |
| 6      | <b>Green SC Performance</b>               | Implementing RL ,Green Design Initiatives ,Green purchasing & marketing ,Green Disposal Initiatives, ,Top management commitment ,Customers Focus                           | Organizational Capabilities ,Green Standard Adaptation, Suppliers management, Technology Innovation, GM planning:, ,Process management   |

## 4. Case Study —M/S Jsw Ispat Steel Limited

### 4.1. Objective of Case Study

To verify whether the relationship established is valid through the responses from the industries. The major aim of the case study is to provide a practical example of performance improvement of the Indian manufacturing company that has implemented GM initiative. One of the objectives of case study was to assess the GM implementation practices and performance improvement of the organization. The study was conducted in company that has already implemented this initiative. The case study helps in evaluating the company's GM implementation and overall business performance.

### 4.2. Brief about the Organisation

The case study was carried out at the downstream steel products manufacturing and servicing facility of JSW ISPAT Steel limited located at Kalmeshwar, Nagpur in the state of Maharashtra, India houses the state of the art technology in the field of cold rolling, galvanizing, color coating, galvalume and pipe and tube. Ispat Industries Limited (IIL) is one of the leading integrated steel makers and the largest private sector producer of hot rolled coils in India. Table 2 shows the detail of capacity of company. In the company's endeavor to be a world-class player, it worked hard to merit the QS: 9000 (Quality System) and ISO:14000 (Environment Management System) certifications

Table 2. Capacity details *Source: Company*

| Facilities          | Capacity (mn tonnes) |
|---------------------|----------------------|
| Cold rolling mill   | 0.330                |
| Galvanising line    | 0.225                |
| Galvalume line      | 0.100                |
| Colour-coating line | 0.060                |

### 4.3. Performance Improvement Programs Pursued by the Company (GM In Company)

The Company has always striven to be responsible and sensitive to ecological and environmental matters. This is ensured by protecting, conserving and restoring all natural resources, often far beyond what is mandated by government and other institutional policies. The Company is committed to complying in full measure with all regulations relating to the preservation of the environment around its operations. By constantly upgrading technologies and by applying the best of sustainable processes and practices, the Company

endeavors to provide environmental issues the priority they deserve.

Table 3. Treated Effluent Details

| Sr no | Type                | Quantity          | Disposal of treated effluent                         |
|-------|---------------------|-------------------|--|
| 1     | Industrial Effluent | 32209 cu m /month | After zero liquid discharge treatment water is reuse |
| 2     | Domestic Effluent   | 9362 cu m /month  | Use on land for gardening plantation                 |

Table 4. Emission details

|   | Parameter          | Emission Norms | Actual | Control Equipment |
|---|--------------------|----------------|--------|-------------------|
| 1 | TPM-Boiler Chimney | 150 mg/ Nm3    | 110    | Bag House         |
| 2 | SO2                | 2028 Kg/Day    | 1580   | Bag House         |

Table 5. Effluent Quality Details

| Parameters      | Norms mg/lit Max | Actual | Control equipment           |
|-----------------|------------------|--------|-----------------------------|
| PH              | 5.5 – 9.6        | 6      | Zero liquid Discharge plant |
| Suspended solid | 100              | 55     |                             |
| BOD             | 100              | 50     |                             |
| COD             | 250              | 155    |                             |
| Oil & Grease    | 10               | 7      |                             |
| TDS             | 2100             | 1720   |                             |
| Chloride        | 600              | 400    |                             |
| sulfate         | 1000             | 800    |                             |
| Zinc            | 5                | 3      |                             |
| Lead            | 0.1              | 0.06   |                             |
| iron            | 5                | 3      |                             |

Table 6. Hazardous Waste Details

| sr | Type (category)              | Consent Quantity | Disposal of Hazardous waste    |
|----|------------------------------|------------------|--------------------------------|
| 1  | Used /Spent oil              | 380 KL /Month    | Sale to authorized recycler    |
| 2  | CRM ETP chemical sludge      | 1010 MT/yr       | Disposal at CHL TSDF, Butibori |
| 3  | CCL ETP chemical sludge      | 18 MT/yr         | Disposal at CHL TSDF, Butibori |
| 4  | Oil contaminant cotton waste | 1.2MT/month      | Disposal at CHL TSDF, Butibori |

The Company is dedicated to constantly improving its performance on prevention of pollution, proper use of natural resources and minimization of any hazardous impact stemming from production, development, use and disposal of any of its products and services. The Company complies with all environmental parameters prescribed under applicable statutes and guidelines of Ministry of Environment and Forests, Central Pollution Control Board and Maharashtra Pollution Control Board. The complex is also well within the environmental norms prescribed under World Bank Policies and guidelines. The complex is ISO

14001 certified. Following tables gives the various details regarding Treated Effluent its quality, Emission and Hazardous Waste Details and its disposal. It also shows the various Green manufacturing Practices implemented in the company since last three years.

**Table 7.** Green manufacturing Practices implemented in the company

| GM Practices                                     | 2011-12    | 2010-11 | 2009-10 |
|--|------------|---------|---------|
| ISO 9000   | √          | √       | √       |
| ISO 14001:2008                                   | √          | √       | √       |
| OHSAS 18001                                      | In process |         |         |
| Environmental Auditing                           | √          | √       | √       |
| Rohs   | √          | √       | √       |
| Design for environment                           |            |         |         |
| LCA, EOL, Close loop & Cradle to Cradle approach | √          | √       | √       |
| Green Disposal Initiatives                       | √          | √       | √       |
| Green Design Initiatives                         |            |         |         |
| Green Standards Adoption                         | √          | √       | √       |
| Suppliers management ,                           | √          | √       | √       |
| Technology Innovation                            | √          | √       | √       |
| GM Planning                                      | √          | √       | √       |
| Green purchasing and marketing                   | √          | √       | √       |
| Implementing RL                                  | √          | √       | √       |

**Table 8.** Energy Conservation

|      | Parameters            | Year 2008-09 | Year 2009-10 | Year 2010-11 |
|------|-----------------------|--------------|--------------|--------------|
| 1 a) | <b>Electricity</b>    |              |              |              |
|      | Purchased Unit        | 1637039      | 2231972      | 1556256      |
|      | Total Unit            | 740.50       | 1142.90      | 864.15       |
|      | Rate/unit             | 4.52         | 5.12         | 5.55         |
| b)   | Own Generation        | 67668.788    | 84656.731    | 61075.346    |
|      | Units/Lit furnace oil | 4.27         | 4.15         | 4.18         |
|      | Cost/unit Rs          | 4.09         | 4.94         | 6.27         |
| 2    | <b>Coal Quantity</b>  | 7079 MT      | 10769 MT     | 8630MT       |
|      | Cost (crore)          | 1.45         | 2.84         | 1.77         |
|      | Avg Rate /unit        | 2062         | 2328         | 2051         |
| 3    | <b>Furnace oil</b>    |              |              |              |
|      | Quantity Ltrs         | 33223        | 26668        | 12250        |
|      | Total Amount (crore)  | 98.82        | 79.02        | 4.58         |
|      | Avg Rate/unit         | 29.74        | 29.63        | 37.39        |

**4.5. Road Map Future Plan (Future Plans for Technology Absorption, Research etc)**

- (ZLDP) Sludge can be use in Industries ( like cement etc)
- Waste heat recovery and Bio gas generation
- More energy conservation
- Oil treatment plant
- Sludge treatment plant
- Horticulture

- Development of additional new facilities for high end value added product (Normalizing facility, Ultrafast cooling system in mill etc.)

- Green or energy efficient Steel, wider range particularly Martensitic stainless steel etc, Product Re-engineering and Brand development.

- In-house adaptation of ultra fast cooling at beginning of Lamellar cooling to produce acicular ferrite, high work hardenable steels for Auto Sector.

- Coordination with JSW R&D, other Research Institutes and technical Universities in India and abroad.

- New product and market development (Green or energy efficient Steel, wider range products, particularly, Martensitic Stainless Steel, APIX70 > 12 mm, Dual Phase, IF steel etc),Product re-engineering and Brand development.

- Process re-engineering for more lean, efficient and effective process.

- Reduction in energy consumption at C.R. Slitter-3 by replacing DC motors and Drives with AC Motors and VVF Drives.

- Maintaining Entry Tension Reel and Delivery Tension Reel Field Economy at minimum level in 6 Hi Cold Rolling Mill to achieve reduction in power consumption.

- Installation of Energy Saver to optimise lighting power consumption in CRM Plant and Street Lighting.

- Replacement of Halogen lamps by Metal Halide to save power at all inspection points in CRM.

- Installation of VVF Drive for three nos. of Cranes.

- Increase transparent roofing sheets in CGL-1 and its Finishing Lines to use day lighting.

- Installation of capacitor bank at HT side to maintain unity power factor

**5. Evaluation of GM Implementation and Organizational Performance**

In order to evaluate the company’s GM implementation practices and organizational performance, the developed research instrument was used. Based on the evaluation, the current situations of the company’s GM implementation and overall performance were obtained. Subsequent sections present the evaluation results, which were translated into marks according to the scoring methods. It also highlights the extent of relationship ( little, moderate, large) between various GM implementation practices and overall performance.

**5.1. Validation of the Research Instrument**

In order to validate the developed model the structured instrument were given to 41 members of the organization. They were requested to complete the instrument in the context of their organization. A workshop to explain the interpretation of the instrument items and the meaning of ‘GM’ Implementation (Performance) Model’ was held.

The developed research instrument can be used by

companies practicing GM approach. It can be used to measure the degree of emphasis of GM implementation and its impact on organizational performance. The research instrument was found to be reliable. It was necessary to validate the research instrument through a case study. The instrument was distributed to forty one employees of the company practicing combined GM approach with prior permission. The responses were analyzed, mean of each item was estimated and items were grouped as respective factors. Further grand mean of all six factors was obtained. The mean of the responses were proportionally marked in consultation with the experts as shown in Table 11. The number “1” means that the company is having Not at all relationship between the implementation factor and the performance measure or it means that the company is extremely weak in this practice, while the “8” indicates that the relationship between the implementation factor and the performance measure is To a very large extent or extremely strong. Similarly for assessing impact of GM on organizational performance the number “1” means Not at all improvement, while the “8” indicates improvement to a very large extent in performance measures of the company. During the process of assessment, the strengths and weaknesses of items of the respective factors were pointed out. Marks above and below “4” indicate strong and weak items respectively. If the company is neither strong nor weak in particular item, it is indicated as “Average” or to a moderate extent. Strong and average terms are just a relative sense compared with the weak term. Based on total marks scored by implementation

factors and performance parameters, the overall grading criterion was decided as shown in Table 10.4. Total marks achieved are indicated as X.

**Table 9.** Mean and proportionate marks

| Mean(Response) | Marks                      |
|----------------|----------------------------|
| 1.00 - 1.50    | 1(Not at all)              |
| 1.51 - 2.00    | 2                          |
| 2.01 - 2.50    | 3                          |
| 2.51 - 3.00    | 4(To a moderate extent)    |
| 3.01 - 3.50    | 5                          |
| 3.51 - 4.00    | 6                          |
| 4.01 - 4.50    | 7                          |
| 4.51 - 5.00    | 8 (To a very large extent) |

**Table 10.** Grading criteria

| Total marks range | Grading |
|-------------------|---------|
| 80 % < X < 90 %   | A       |
| 70 % < X < 80 %   | B       |
| 60 % < X < 70 %   | C       |
| 50 % < X < 60 %   | D       |
| X < 50 %          | E       |

Table 11 to Table 22 illustrates the detailed analysis of the measure the degree of emphasis of GM implementation. It highlights grand mean, corresponding marks and strengths and weaknesses of addressed items of the factors from research instrument.

**Table 11.** Assessment result – Factor 1: Organizational Capabilities

| Addressed items of the factors   | Mean | Grand Mean | Max Marks | Extent of Relationship |
|--|------|------------|-----------|------------------------|
| Organizational Capabilities Leads to Improvement in Financial and Manpower performance | 4.36 | 4.04       | 7         | Large                  |
| Organizational Capabilities Leads to Improvement in Operational Performance            | 4.24 |            |           | Large                  |
| Organizational Capabilities Leads to Improvement in Competitive advantages             | 3.83 |            |           | Large                  |
| Organizational Capabilities Leads to Continuous improvement                            | 3.76 |            |           | Large                  |
| Organizational Capabilities Leads to Improvement in Stakeholders Enrichment            | 3.81 |            |           | Moderate               |
| Organizational Capabilities Leads to Improvement in Green SC Performance               | 3.80 |            |           | Large                  |

**Table 12.** Assessment result – Factor 2 : Green Design Initiatives

| Addressed items of the factors  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| Green Design Initiatives Leads to Improvement in Financial and Manpower Performance | 4.18 | 4.01       | 7         | Large                  |
| Green Design Initiatives Leads to Improvement in Operational Performance            | 4.17 |            |           | Large                  |
| Green Design Initiatives Leads to Improvement in Competitive advantages             | 4.27 |            |           | Large                  |
| Green Design Initiatives Leads to Continuous Improvement                            | 4.27 |            |           | Large                  |
| Green Design Initiatives Leads to Improvement in Stakeholders Enrichment            | 2.43 |            |           | Little                 |
| Green Design Initiatives Leads to Improvement in Green SC Performance               | 4.35 |            |           | Large                  |

**Table 13.** Assessment result – Factor 3: Green Standards Adoption

| Addressed items of the factors  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| Green Standards Adoption Leads to Improvement in Financial and Manpower performance | 4.10 | 3.98       | 6         | Large                  |
| Green Standards Adoption Leads to Improvement in Operational Performance            | 4.00 |            |           | Large                  |
| Green Standards Adoption Leads to Improvement in Competitive advantages             | 4.17 |            |           | Large                  |
| Green Standards Adoption Leads to Continuous Improvement                            | 3.90 |            |           | Large                  |
| Green Standards Adoption Leads to Improvement in Stakeholders Enrichment            | 3.78 |            |           | Large                  |
| Green Standards Adoption Leads to Improvement in Green SC Performance               | 3.93 |            |           | Large                  |

**Table 14.** Assessment result – Factor 4 : Suppliers Management,

| Addressed items of the factors   | Mean | Grand Mean | Max Marks | Extent of Relationship |
|--|------|------------|-----------|------------------------|
| Suppliers Management, Leads to Improvement in Financial and Manpower performance | 3.88 | 4.01       | 7         | Large                  |
| Suppliers Management, Leads to Improvement in Stakeholders Enrichment            | 4.10 |            |           | Large                  |
| Suppliers Management, Leads to Improvement in Green SC Performance               | 4.05 |            |           | Large                  |

**Table 15.** Assessment result – Factor5 Technology Innovation

| Addressed items of the factors   | Mean | Grand Mean | Max Marks | Extent of Relationship |
|--|------|------------|-----------|------------------------|
| Technology Innovation Leads to Improvement in Financial and Manpower performance | 4.12 | 4.26       | 7         | Large                  |
| Technology Innovation Leads to Improvement in Operational Performance            | 4.44 |            |           | Large                  |
| Technology Innovation Leads to Continuous Improvement                            | 4.22 |            |           | Large                  |

**Table 16.** Assessment result – Factor6 GM Planning

| Addressed items of the factors                              | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| GM Planning Leads to Improvement in Operational Performance | 4.05 | 3.81       | 6         | Large                  |
| GM Planning Leads to Continuous Improvement                 | 3.80 |            |           | Large                  |
| GM Planning Leads to Improvement in Stakeholders Enrichment | 3.59 |            |           | Large                  |

**Table 17.** Assessment result – Factor7 Green purchasing & marketing

| Addressed items of the factors  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| Green purchasing & marketing Leads to Improvement in Financial and Manpower performance | 4.10 | 4          | 7         | Large                  |
| Green purchasing & marketing Leads to Improvement in Operational Performance            | 4.10 |            |           | Large                  |
| Green purchasing & marketing Leads to Improvement in Competitive advantages             | 4.34 |            |           | Large                  |
| Green purchasing & marketing Leads to Continuous Improvement                            | 4.07 |            |           | Large                  |
| Green purchasing & marketing Leads to Improvement in Stakeholders Enrichment            | 3.51 |            |           | Large                  |
| Green purchasing and marketing Leads to Improvement in Green SC Performance             | 4.10 |            |           | Large                  |

**Table 18.** Assessment result – Factor 8 Implementing RL

| Addressed items of the factors   | Mean | Grand Mean | Max Marks | Extent of Relationship |
|--|------|------------|-----------|------------------------|
| Implementing RL Leads to Improvement in Financial and Manpower performance | 3.93 | 4.07       | 7         | Large                  |
| Implementing RL Leads to Improvement in Operational Performance            | 3.90 |            |           | Large                  |
| Implementing RL Leads to Improvement in Competitive advantages             | 4.27 |            |           | Large                  |
| Implementing RL Leads to Continuous Improvement                            | 3.90 |            |           | Large                  |
| Implementing RL Leads to Improvement in Stakeholders Enrichment            | 4.10 |            |           | Large                  |
| Implementing RL Leads to Improvement in Green SC Performance               | 4.29 |            |           | Large                  |

**Table 19.** Assessment result – Factor 9 Top management Commitment

| Addressed items of the factors   | Mean | Grand Mean | Max Marks | Extent of Relationship |
|--|------|------------|-----------|------------------------|
| Top management Commitment Leads to Improvement in Financial and Manpower performance | 3.88 | 4.03       | 7         | Large                  |
| Top management Commitment Leads to Improvement in Operational Performance            | 4.10 |            |           | Large                  |
| Top management Commitment Leads to Improvement in Competitive advantages             | 3.93 |            |           | Large                  |
| Top management Commitment Leads to Continuous Improvement                            | 4.34 |            |           | Large                  |
| Top management Commitment Leads to Improvement in Stakeholders Enrichment            | 3.68 |            |           | Large                  |
| Top management Commitment Leads to Improvement in Green SC Performance               | 4.24 |            |           | Large                  |

**Table 20.** Assessment result – Factor10 Customers Focus

| Addressed items of the factors                                  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| Customers Focus Leads to Continuous Improvement                 | 4.20 | 4.07       | 7         | Large                  |
| Customers Focus Leads to Improvement in Stakeholders Enrichment | 3.71 |            |           | Large                  |
| Customers Focus Leads to Improvement in Green SC Performance    | 4.32 |            |           | Large                  |

**Table 21.** Assessment result – Factor11 Green Disposal initiatives

| Addressed items of the factors  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| Green Disposal initiatives Leads to Improvement in Financial and Manpower performance | 3.71 | 3.76       | 6         | Large                  |
| Green Disposal Initiatives Leads to Improvement in Operational Performance            | 3.61 |            |           | Large                  |
| Green Disposal Initiatives Leads to Improvement in Competitive advantages             | 3.54 |            |           | Large                  |
| Green Disposal Initiatives Leads to Continuous Improvement                            | 4.05 |            |           | Large                  |
| Green Disposal Initiatives Leads to Improvement in Stakeholders Enrichment            | 3.54 |            |           | Large                  |
| Green Disposal Green SC Initiatives Leads to Improvement in Green SC Performance      | 4.15 |            |           | Large                  |

**Table 22.** Assessment result – Factor12 Process management

| Addressed items of the factors  | Mean | Grand Mean | Max Marks | Extent of Relationship |
|---|------|------------|-----------|------------------------|
| process management Leads to Improvement in Financial and Manpower performance | 4.49 | 4.09       | 7         | Large                  |
| process management Leads to Improvement in Operational Performance            | 3.98 |            |           | Large                  |
| process management Leads to Improvement in Competitive advantages             | 3.76 |            |           | Large                  |
| process management Leads to Continuous Improvement                            | 4.34 |            |           | Large                  |
| process management Leads to Improvement in Stakeholders Enrichment            | 3.98 |            |           | Large                  |
| process management Leads to Improvement in Green SC Performance               | 2.98 |            |           | Moderate               |



**Table 23.** Mean and F value of ANOVA

| Performance measure<br>Critical success factor | Financial and<br>Manpower | Operational<br>Performance | Competitive<br>advantages | Continuous<br>Improvement | Stakeholders<br>Enrichment | Green SC<br>Performance |
|--|---------------------------|----------------------------|---------------------------|---------------------------|----------------------------|-------------------------|
| <b>1 Organizational Capabilities</b>           | 4.099<br>(2.705)*         | 4.236<br>(1.968)           | 3.756<br>(2.437) *        | 3.721<br>(2.106)          | 3.423<br>(1.427)**         | 3.803<br>(1.644)        |
| <b>2 Green Design Initiatives</b>              | 3.929<br>(1.598)**        | 4.082<br>(0.753)*          | 4.256<br>(0.698)*         | 4.072<br>(0.704)*         | 3.801<br>(4.159)**         | 4.204<br>(0.848)**      |
| <b>3 Green Standards Adoption</b>              | 4.049<br>(1.390)**        | 3.992<br>(0.167)*          | 4.203<br>(0.202)*         | 3.857<br>(0.551)**        | 3.758<br>(1.745)**         | 3.962<br>(1.452)*       |
| <b>4Suppliers management</b>                   | 3.842<br>(1.718)**        |                            |                           |                           | 4.082<br>(0.979)           | 4.044<br>(0.628)        |
| <b>5Technology Innovation</b>                  | 4.103<br>(2.412)*         | 4.461<br>(0.217)           |                           | 4.204<br>(0.398)          |                            |                         |
| <b>6GM Planning</b>                            |                           | 4.065<br>(1.003)           |                           | 3.819<br>(0.573)          | 3.583<br>(4.812)**         |                         |
| <b>7Green purchasing and marketing</b>         | 4.078<br>(1.096)          | 4.101<br>(2.250)*          | 4.316<br>(2.882*)         | 4.062<br>(1.565)          | 3.520<br>(1.489)           | 4.068<br>(2.268)*       |
| <b>8Implementing RL</b>                        | 3.896<br>(2.180)          | 3.873<br>(3.436)**         | 4.260<br>(4.320)**        | 3.857<br>(0.989)          | 4.061<br>(3.256)**         | 4.286<br>(3.607)**      |
| <b>9 Top management Commitment</b>             | 3.888<br>(1.263)          | 4.091<br>(2.707)*          | 3.959<br>(1.762)          | 4.314<br>(3.922)*         | 3.678<br>(5.15)**          | 4.221<br>(1.938)        |
| <b>10customers Focus</b>                       |                           |                            |                           | 4.181<br>0.453            | 3.717<br>(2.894)**         | 4.297<br>(2.112)        |
| <b>11Green Disposal Initiatives</b>            | 3.714<br>(1.160)          | 3.610<br>(2.895)**         | 3.582<br>(3.073)**        | 4.026<br>(1.943)          | 3.541<br>(1.982)           | 4.153<br>(2.371)*       |
| <b>12 process management</b>                   | 4.450<br>(0.658)          | 3.971<br>(0.083)           | 3.807<br>(2.609)*         | 4.306<br>(0.551)          | 3.982<br>(0.476)           | 3.995<br>(2.193)        |

\*\* . Significant at the 5% level \* . Significant at the 10 % level

Based on above analysis, overall grade of the company was estimated as follows.

Numerical weightage assigned to each factor/performance parameter = 8 marks

Number of factors = 12

Maximum marks (12\*8) = 96

Total marks achieved = 81

% marks achieved = 84.37 %

Overall grade = A

The overall grade achieved as per grading criteria is A. Thus by using the developed research instrument the degree of emphasis of GM implementation and its impact on organizational performance was measured. Through the assessment of the company’s GM practice and overall business performance, most of the established relationship as per the derived model between the implementation factors and the performance measures of the company come to be large to very large extent. Relationship such as organizational capabilities leads to Improvement in stakeholders enrichment is identified as moderate relationship. Whereas Green Design Initiatives Leads to Improvement in Stakeholders enrichment comes to be very little extent relationship. Lower marked practices (e.g. lower than or equal to 4) should be given more attention by the company. These weaknesses could be used as improvement possibilities for further improving the company’s GM implementation. Thus the developed research instrument is validated and it can be used by companies practicing GM approach.

## 6. Validation of GM Implementation (Performance) Model (Mean and F value of ANOVA)

The collected data was analyzed and one way Analysis of Variance (ANOVA) is carried out to identify the difference between the perceptions of various level of management and mean factor of GM factors(Independent and dependent). The various level of management is classified as Sr.Manager /Manager/Sr officer, Asst./Deputy/officer/engg, Jr.Manager/officer and Technician/Supervisor/trainee. The mean factor score of the factors extracted from the GM Independent and dependent factors are tested to identify whether it differs from various level of management or not .The descriptive statistics are shown in table 24.

From the Table 23 it is evident that for success factor Organizational Capabilities, the calculated F value for Company are 2.705 which is significant at 10% level. Similarly the mean value for Company are 4.099, which is at higher side. Hence it can be concluded that there is a significant improvement in organizations Financial and Manpower performance by Organizational Capabilities. Hence the relationship between Organizational Capabilities and Financial and Manpower performance is considered as significant. Similarly Organizational Capabilities plays vital role and leds to improvement in

other organizations performance measures like Operational Performance, Competitive advantages, Continuous Improvement, Stakeholders Enrichment and Green SC Performance . Hence the relationship between Organizational Capabilities and organizational performance measures are considered as significant.

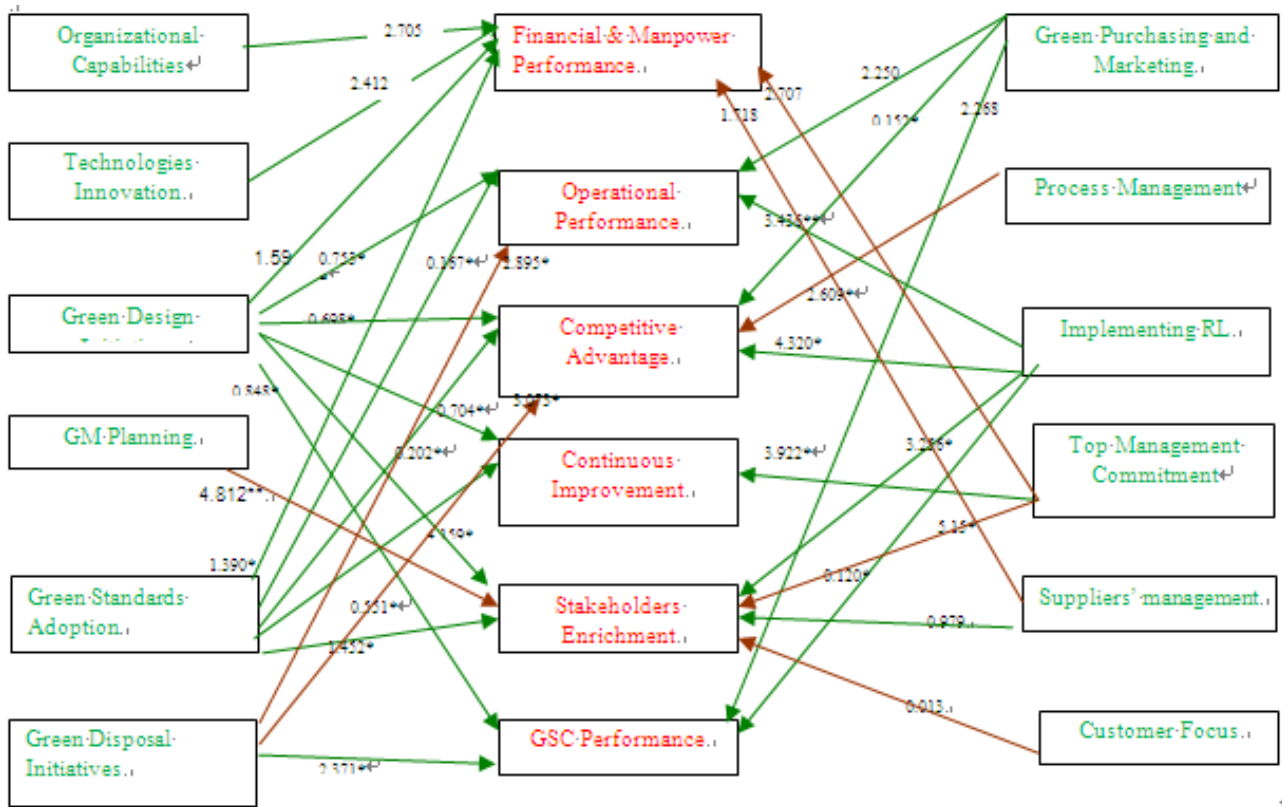


Figure 4 Model for Company

For Green Design Initiatives, the calculated F value is, 1.598 which is significant at the 10% level for firm. Similarly the mean value for Company are 3.929, which is at higher side. Hence it can be concluded that there is a significant improvement in organizations Financial and Manpower performance through Green Design Initiatives. Hence the relationship between Green Design Initiatives and Financial and Manpower performance is considered as significant. Similarly Green Design Initiatives plays vital role and leads to improvement in other organizations performance measures like Operational Performance, Competitive advantages, Continuous Improvement, Stakeholders Enrichment and Green SC Performance . Hence the relationship between Green Design Initiatives and organizational performance measures are considered as significant. After going through the values of F and mean for critical success factors like Green Standards Adoption, Green purchasing and marketing, Top management Commitment, Green Disposal Initiatives and process management it can be concluded that there is a significant improvement in organizations performance measures through this critical success factors. Hence the relationship between this are considered as significant.

GM Model for company shows the relationship like GM planning leads to Stakeholders Enrichment, Green Disposal

Initiatives leads to Operational Performance & Competitive advantages, Process management Initiatives leads to Competitive advantages, Top management commitment leads to Financial performance and Manpower Performance & Stakeholders Enrichment, Suppliers management leads to Financial performance and Manpower Performance, Customers Focus leads to Stakeholders Enrichment are added in existing mathematical model which is already drawn. Whereas the relationship which are deleted from existing model are Technology Innovation leads to Operational Performance, GM planning leads to Continuous Improvements, Green purchasing & marketing leads to Financial performance and Manpower Performance, Process management leads to Operational Performance, Implementing RL leads to Financial performance and Manpower Performance & Continuous Improvements, Customers Focus leads to Green SC Performance.

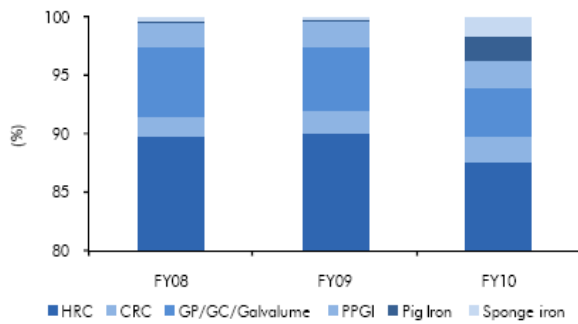
Thus from the above discussion it is found that significant relationship exist between implementation factors and performance measures of companies which ultimately validates the derived model. The Derived GM implementation model shows 34 number of significant relationship between organizations performance measures and GM Critical Success Factors. From the analysis result it can be shown that , the Company is having 31 number of

significant relationships between organizations performance measures and GM Critical Success Factors. Hence it can be concluded that the GM Implementation (Performance) model derived in this research study is strongly validated as the two GM practicing Indian industries are following this to a great extent. The GM Implementation (Performance) model derived in this research study is valid for Indian industries who are implementing Green manufacturing technique or who desire to implement GM technique in future.

The data of the company’s overall business performance could be used as input for formulating an effective improvement plan. Therefore, evaluating overall business performance was also an important part of GM implementation. In fact, this performance reflected the effects of the company’s GM implementation. For assessing the impact of GM practices on the organizational performance the performance parameters were compared for last three years and discussed in further sections. For measuring strategic business performance, the addressed areas are listed in the first column. The results are listed in the second to fourth columns. The strengths and weaknesses are listed in the fifth column (Table 12, Table 23).

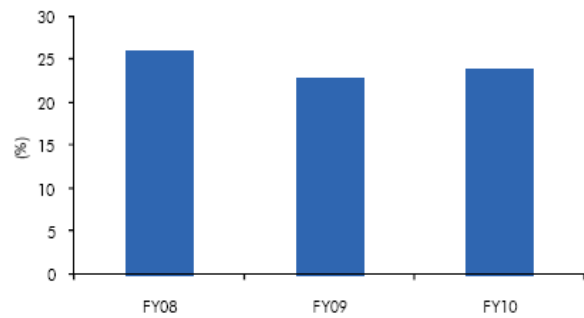
### 7. Impact of GM Implementation on Organizational Performance

**Exhibit 5: Product-wise sales volume breakup**



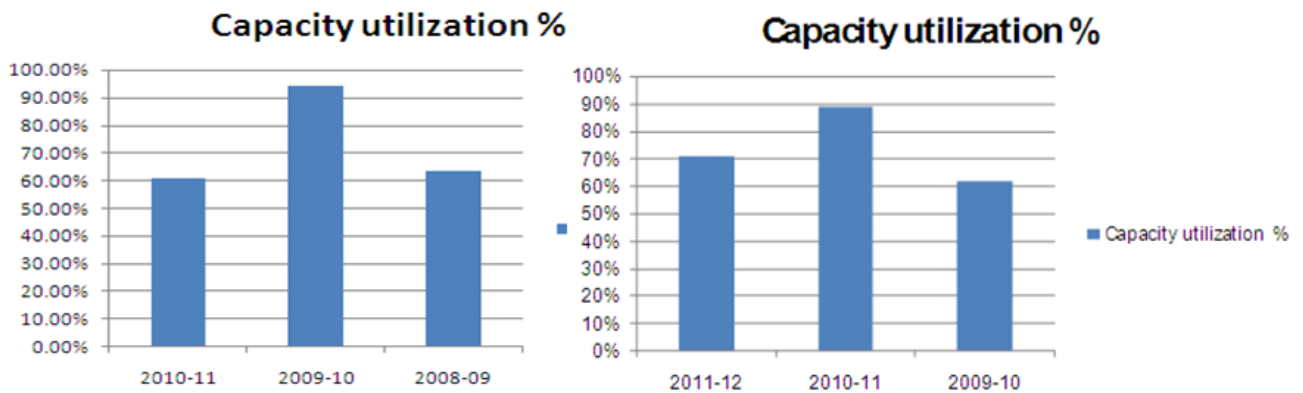
Source: Company, Angel Research

**Exhibit 6: Value-added product accounts for 25%**



Source: Company, Angel Research

**Figure 5.** sales growth (for company A)



**Figure 6.** capacity utilization for last three years for steel and Galvanized coils respectively

**Table 24.** Year wise growth of the company

| Parameters / Fin year          | Year 2008-09      | Year 2009-10       | Year 2010-11     |
|--------------------------------|-------------------|--------------------|------------------|
| Total Sales Income             | 9063.44 Cr        | 10983.14           | 8990.07          |
| Exports                        | 719.85 cr         | 433.44 cr          | 486.14 cr        |
| Increase in Production         |                   |                    |                  |
| Cold Rolled Steel Coils/Sheets | 0.2 Million MTs   | 0.31 Million MTs   | 0.21 Million MTs |
| Galvanized Coils/Sheets        | 0.16 Million MTs, | 0.20 Million MTs., | 0.14 Million MTs |
| % age Capacity Utilization     |                   |                    |                  |
| Cold Rolled Steel Coils/Sheets | 60.6%             | 93.93%             | 63.63%           |
| Galvanized Coils/Sheets        | 71.11%            | 88.9%              | 62.22%           |

### 7.1. Overall Growth of the Company Due to GM Practice

The company regularly measured its annual sales, capacity utilization, market share and exports. The indices of these indicators between 2010-11 and 2008-09 are listed in Table 24. The annual sales of the company have increased by 22 % over the years. Similarly capacity utilization and market share have also increased. There is incredible increase in export of the company. This indicates the positive effect of the company's GM implementation. Productivity is one of the key indicators of organizational performance. The productivity target (in terms of sales) fixed by the company and actually achieved in the particular year are shown in Table 24 for past three years. In this company production is stated in terms of sales amount. It also represents year wise sales growth of the company which indicates improvement in productivity over the years.

In spite of these adverse factors company has initiated various efforts to reduce the cost of production. In this company various cost reduction measures were adopted. The measures are:

- usage of alternate grades of raw material, successful in-house commissioning of natural gas injection in blast furnace and lower usage of fluxes
- Installation of Acid Regeneration Plant (ARP) leads to Recycling of waste
- ARP byproduct (iron oxide ) sales
- Zero Liquid Discharge Plant (ZLDP) recovers 100% water waste
- (ZLDP) leads to oil recovery
- Reuse of water in boiler
- Up-gradation of existing Vapor Absorption Machine and further utilization of chilled water in AC s to reduce power consumption.
- Carbon foot print measurement study being conducted to further Carbon reduction opportunities and identification of CDM projects and develop carbon reduction strategy and set emission reduction targets.
- Installation of Magna drive/ coupling.
- Installation of solar panels in building roof tops.
- Reduction in energy consumption at C.R. Slitter-3 by replacing DC motors and Drives with AC Motors and VVF Drives.
- Maintaining Entry Tension Reel and Delivery Tension Reel Field Economy at minimum level in 6 Hi Cold

## 8. Conclusion

The developed research instrument has been validated. It can be used by other manufacturing companies practicing GM initiatives. The case study highlights the weak areas which can be used as possibilities for the company to improve its GM implementation and overall business performance. However, it should be noted that even its strong areas are not at all perfect as indicated by marks scored by respective items; they still have room for

improvement. Strong and average areas are just a relative sense compared with the company's weak areas, though weak areas should receive more attention. The weak areas of the company's GM implementation can be used by the company to formulate improvement plans. The various performance indicators show remarkable improvement over the years. The company has achieved both tangible and intangible benefits by practicing this approach. The case study shows that GM approach can be used to benchmark company's continuous improvement, self-assess their quality improvement efforts and measure their progress over time. Through this, company can quickly identify which areas urgently need improvement. Thus, resources can be allocated more wisely.

The results obtained from the implementation of GM initiative were encouraging for the organizations, and also substantiated the model. The organizations also benefited through the improvement in various areas and because of GM implementation the organizations have continuously improved their performances. In the process the organizations received appreciations from their customers and also gained significant benefits through GM implementation. The concerns also certified that 'The GM Implementation (Performance) Model' developed by the researcher through his research study served as a useful guidance in successfully implementing GM practices in their organizations and in achieving better organizational performance.

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