Validating quality productivity improvement framework for sponge iron industry in India

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In this work, an attempt has been made to validate the quality–productivity improvement framework developed for sponge iron (SI) industry, through its implementation in two different SI plants. The study proved that the developed framework is valid and reliable for coal-based SI industry in India. The same framework may be implemented elsewhere in the world with little modification according to the prevailing environment in that country. The concept can also be expanded to other fields.

Keywords: quality; productivity; sponge iron; critical success factors; performance measurement factors

1. Introduction

Identification of critical success factors (CSFs), performance measurement factors (PMFs), and its relation with each other (called as framework) for particular industry helps improving the desired parameters through its implementation. However, developed framework must be validated by implementing it in representative unit. Through the literature review, it was noticed that the quality–productivity improvement framework has not yet been developed for sponge iron (SI) industry anywhere in the world. The authors have developed a framework empirically for coal-based SI industry in India and validated it through its implementation in two different SI plants.

2. Literature review

India accounted for major share of global SI production and has occupied the top slot across the globe. With the country’s strong economic environment, the industry prospects are certainly bright. There has been an inspiring track record of growth of SI industry in India during the last decade.

Table 1 shows the data from the ministry of steel about production of gas and coal-based SI in India from 2006–2007 to 2012–2013; while Table 2 shows segment-wise production and capacity utilization for year 2010–2012. Reduced growth rate in the year 2012 demands something to be done towards the improvement in quality and productivity in SI industry. Figure 1 shows the graph of production of SI from 2000 to 2010.

The year 2011–2012 was the year of political turmoil in India. A lot of policy changes have occurred which affected the SI industry, directly or indirectly. Availability

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of iron ore and coal reduced drastically. Many units could not operate to its full capacity. Efforts for quality and productivity improvement were totally at bay. However, few companies (e.g. Tata Sponge Iron Ltd) still managed to earn the profit, resulting from their efforts for quality and productivity improvement through total quality

Table 1. Production of SI in India.

| Year     | Production of SI (in MT) |       |       |
|----------|--------------------------|-------|-------|
|          | Gas based                | Coal based | Total (gas + coal) based (in MT) |
| 2006–2007| 5.26                     | 13.08  | 18.34 |
| 2007–2008| 5.84                     | 14.53  | 20.37 |
| 2008–2009| 5.52                     | 15.57  | 21.09 |
| 2009–2010| 6.15                     | 18.18  | 24.33 |
| 2010–2011| 5.79                     | 20.92  | 26.71 |
| 2011–2012| 5.17                     | 15.20  | 20.37 |
| 2012–2013(Apr–Dec) | 3.23*               | 11.66* | 14.89* |

Source: Annual Report (2011–2012), and Annual Report (2012–2013), Ministry of Steel.

*Indicates the production for three quarters.

Table 2. Segment-wise production and capacity utilization in India.

| Particulars           | 2010–2011 | 2011–2012 | % Growth |
|-----------------------|-----------|-----------|----------|
| (A) Gas-based units – production (tons) | 6,189,917 | 5,150,018 | (−) .83  |
| Annual installed capacity (lakh tons) | 96       | 96        |          |
| Capacity utilization (%) | 64.47    | 53.64     |          |
| (B) Coal-based units – production (tons) | 17,065,432 | 15,407,645 | (−) .90  |
| Annual installed capacity (lakh tons) | 253.35   | 257.9     |          |
| Capacity utilization (%) | 67.35    | 59.93     |          |
| Grand total (A + B)    | 23,255,349 | 20,557,663 | (−) .88  |
| Total capacity (lakh tons) | 349.35    | 353.09    |          |
| Overall capacity utilization | 66.56    | 58.22     |          |

Source: [www.spongeironindia.in/prodfig0607.html](http://www.spongeironindia.in/prodfig0607.html), The official website of SIMA India, Retrieved from 10 January 2013.

Figure 1. India’s SI production.
Source: Ore Team Research (2011).
management (TQM) proving the importance and necessity of implementation of TQM in SI industry in India. (www.spongeironindia.in/presentations/PCTATASPONGESIMAPresentation100912.pdf, Retrieved from 22 December 2012; www.tatasponge.com/investor/annualreports/annualreport2010-11.pdf, Retrieved from 10 November 2012; www.tatasponge.com/investor/annualreports/annualreport2011-12.pdf, Retrieved from 10 January 2013.)

During 80s, there was a great demand for SI due to shortage of scrap. Moreover, many new SI plants were established after 1985. Thus, during 80s, quality of SI was not an important factor as there was a huge demand due to the shortage of scrap. Very little attention was paid to the quality and productivity of SI. But as the competition grew, there was a need to focus on the quality and the productivity improvement to survive. After the formation of SIMA i.e. Sponge Iron Manufacturers Association in 1992, the manufacturers had to set standards of quality of SI. Thus, quality of SI gradually began a point of concern in the past.

2.1. Targeted vs. achieved SI production in India

Table 3 shows the data for targeted production and achieved production for gas-based and coal-based SI manufacturing in India for the year 2004–2005 to 2011–2012.

The graph drawn from the data from Table 3 is shown in Figure 2. It is clear from the figure that the achieved production is always less than the targeted production in coal-based SI plants. This fact demands the need for identification and validation of critical factors affecting quality and productivity in coal-based SI industry.

2.2. Problems of SI industry in India

A panoramic view through the review of Sengupta (2000), Sengupta (2001), Pandit, Sarangi, Babu, and Sheshadri (2003), Sengupta (2005), Raju (2005), Raja and Pal (2006), Kalluraya, Ramchandra, and Srinivasan (2006), Battacharjee (2007), Equitymaster.com (2009), Sengupta (2009), Khattoi (2010), Reddy (2010), Borwankar (2011), Infocus (2011), Sengupta (2011), Steel Sector Analysis Report (2011), Dhopatkar (2012), Invest India (2012), Kashiva (2012), Scribe.com (2012), and Sengupta (2012a, 2012b), etc. indicates the SI industry with investments of over Rs. 5000 crore contributing more than Rs. 450 crore per annum by way of taxes to the national exchequer, saving sub-

Table 3. Targeted vs. achieved production for gas- and coal-based SI in India.

| Year      | Targeted production (MT) | Achieved production (MT) |
|-----------|--------------------------|---------------------------|
|           | Gas-based | Coal-based | Total | Gas-based | Coal-based | Total |
| 2004–2005 | 6.1       | 6.0        | 12.1  | 4.6       | 5.5        | 10.1  |
| 2005–2006 | 6.1       | 8.5        | 14.6  | 5.7       | 6.5        | 12.2  |
| 2006–2007 | 7.1       | 11.0       | 18.1  | 7.0       | 8.5        | 15.5  |
| 2007–2008 | 7.1       | 13.0       | 20.1  | 7.0       | 10.0       | 17.0  |
| 2008–2009 | 7.1       | 17.0       | 24.1  | 7.0       | 15.3       | 22.3  |
| 2009–2010 | 7.1       | 18.0       | 25.1  | 7.0       | 14.0       | 21.0  |
| 2010–2011 | 9.6       | 25.34      | 34.94 | 6.19      | 17.07      | 23.26 |
| 2011–2012 | 9.6       | 25.34      | 34.94 | 5.15      | 15.41      | 20.56 |

Source: Chatterjee (2010) and www.steelguru.com, Retrieved from 10 June 2014.
stantial foreign exchange and employing directly and indirectly nearly 1,25,000 people. On the other hand, it is also an industry which is under tremendous viability pressure due to raw material availability and pricing constraints. Selling prices are determined by market forces, whereas all input costs are controlled by the government. The problems of the SI industry are:

- The cost of basic inputs like iron ore, coal, and gas have steeply gone up.
- All input costs (administered pricing) are higher in India than overseas.
- Inputs/services for SI production are mainly in government hands.
- High cost of capital.
- Slowdown of economy, resulting in demand recession.
- Availability of right grade and quality of non-coking coal is a must to optimize cost of production of SI. Indian coal having high-ash content (30–35%) will necessarily have to be blended with imported low-ash content coal (below 12%). Therefore, reduction of custom duty on non-coking coal (below 12% ash content) for metallurgical use is necessary.
- High prices of natural gas in comparison to international prices and cost of production resulting from high input cost and inadequate export incentives.

Table 4. List of CSFs (input factors) and PMFs (output factors).

| Critical success factors (CSFs)/input factors | Performance measurement factors (PMFs)/output factors |
|-----------------------------------------------|------------------------------------------------------|
| IF 1: Process management                       | OF 1: Productivity improvement                       |
| IF 2: Top management commitment                | OF 2: Business result                                |
| IF 3: Employee involvement                     | OF 3: Employee satisfaction                          |
| IF 4: Organization culture                     | OF 4: Time dimension                                 |
| IF 5: Effective networking                     | OF 5: Customer satisfaction                          |
| IF 6: Quality assurance                         | OF 6: Quality performance                            |
| IF 7: Competitive assessment                   |                                                      |
| IF 8: Training                                 |                                                      |

Figure 2. Gas- and coal-based, targeted vs. achieved production of SI in India.
• The iron ore used as a raw material for SI needs to be of higher quality with more than 62% Fe content. Currently, out of India’s estimated reserves of 25 billion tons of iron ore, higher grade constituents are only about 8.7%.

Thus, the various gaps those have been identified are as follows:

(1) Large numbers of SI plants have come up with small capacity of 50–100 TPD due to government’s de-licensing policy. They are relatively new and facing many problems. They are coal-based due to large availability of non-coking coal and availability of technology. However, for the sake of higher and higher production, Quality and productivity is highly neglected. In the present crisis of closure of many plants, an urgent need has been generated to take care of quality and productivity in SI industry.

(2) Most of the plants are run in traditional ways. Thumb rules and conventional knowledge is employed for getting the work done. Except very few plants, awareness of quality management system is extremely poor and its implementation is the matter of concern.

(3) Exhaustive literature review indicated that CSFs and PMFs for SI industry have not yet been derived. An attempt was made by Gorantiwar, Kshirsagar, and

Table 5. Multiple regression analysis.

| IF | OF – 1: Productivity improvement | OF – 2: Business result | OF – 3: Employee satisfaction | OF – 4: Time dimension | OF – 5: Customer satisfaction | OF – 6: Quality performance |
|----|---------------------------------|-------------------------|-------------------------------|-----------------------|-------------------------------|-----------------------------|
| IF – 1: Process management | .223 | .472 | .270 | .227 | -.039 | .305 |
| | (2.641)** | (6.694)** | (3.161)** | (2.967)** | (-.380) | (3.602)** |
| IF – 2: Top management commitment | .209 | .147 | .112 | -.060 | .283 | .184 |
| | (2.993)** | (2.223)* | (1.403) | (-.785) | 3.470)** | (2.421)* |
| IF – 3: Employee involvement | .179 | .138 | .272 | .298 | .185 | .099 |
| | (2.418)* | (1.890) | (3.333)** | (3.824)** | (2.270)* | (1.165) |
| IF – 4: Organization culture | .136 | .254 | .150 | .054 | .052 | .105 |
| | (2.186)* | (4.196)** | (2.277)* | (.800) | (1.710) | (1.561) |
| IF – 5: Effective networking | -.272 | -.137 | -.042 | .305 | .015 | .003 |
| | (5.676)** | (2.931)** | (-.767) | (6.198)** | (.247) | (.042) |
| IF – 6: Quality assurance | .186 | -.038 | -.002 | -.061 | .067 | .274 |
| | (3.391)** | (-.693) | (-.036) | (-1.018) | (.982) | (4.075)** |
| IF – 7: Competitive assessment | .044 | .086 | .001 | -.004 | -.020 | -.110 |
| | (.746) | (1.624) | (.019) | (-.061) | (-.337) | (1.975)* |
| IF – 8: Training | .029 | .083 | .082 | .062 | -.026 | .049 |
| | (.514) | (1.481) | (1.308) | (.999) | (-.385) | (.738) |
| R² | .7463 | .7483 | .6253 | .6656 | .4370 | .6285 |
| | .557 | .560 | .391 | .443 | .191 | .395 |
| F-value | 53.768** | 82.439** | 55.577** | 69.049** | 30.772** | 42.230** |
| Intercept | 2.210 | 2.127 | 2.392 | 2.345 | 3.051 | 2.632 |

*Indicates one tailed significance.
**Indicates two tailed significance.
Shrivastava (2011), to identify the factors affecting quality and productivity in direct-reduced iron (DRI) industry; however, it was limited to small region and it lacked validation.

(4) Available literature indicates that no attempt has yet been made to evolve quality–productivity improvement framework for SI industry anywhere in the world.

(5) There is a need to understand the correlation between CSFs and PMFs for appropriate allocation of resources for better performance of SI industry.

To fulfill the gap, authors have developed the framework for coal-based SI industry in India. The framework is represented in the form of models as given in the section below.

3. Models for SI industry

The data collected from the respondents through a specially prepared instrument was analyzed for factor analysis which resulted into eight CSFs & six PMFs for coal-based SI industry in India as listed in Table 4.

![Figure 3. Graphical representation of regression analysis.](image-url)
The data were regressed to find out the relations between output factors and input factors. Table 5 shows the result of multiple regression analysis. Software SPSS V 20 was used (George & Mallery, 2009; Gupta & Gupta, 2011; IBM SPSS, n.d.; Kerr, Hall, & Kozub, 2002; SPSS online, n.d.). Red color values in the table show significant relations, blue color values show moderate significant relations, and green color values show less significant relations.

The graphical representation of regression analysis is shown in Figure 3.

The regression analysis has resulted into six models for quality–productivity improvement in coal-based SI industry in India as below. They show the relations between output factors and input factors as follows:

1. \[ OF_1 \ (Productivity \ Improvement) = 2.210 + .223 \ (IF1) + .209 \ (IF2) + .179 \ (IF3) + .136 \ (IF4) - .272 \ (IF5) + .186 \ (IF6) \]
2. \[ OF_2 \ (Business \ Result) = 2.127 + .472 \ (IF1) + .147 \ (IF2) + .254 \ (IF4) - .137 \ (IF5) \]
3. \[ OF_3 \ (Employee \ Satisfaction) = 2.392 + .270 \ (IF1) + .272 \ (IF3) + .150 \ (IF4) \]
4. \[ OF_4 \ (Time \ Dimension) = 2.345 + .227 \ (IF1) + .298 \ (IF3) + .305 \ (IF5) \]
5. \[ OF_5 \ (Customer \ Satisfaction) = 3.051 + .283 \ (IF2) + .185 \ (IF3) \]
6. \[ OF_6 \ (Quality \ Performance) = 2.632 + .305 \ (IF1) + .184 \ (IF2) + .274 \ (IF6) - .110 \ (IF7) \]

Input factors and their contribution in every performance measure can be observed from equations above. It helps managers to allocate the proper share of resources to input factors so as to get desired performance.

4. Validation of models

Model validation is done through model implementation called as case study. According to Zainal (2007), case study is a robust research methodology, when a holistic and in-depth investigation is needed. Case study gives chance to study one aspect of a real-world problem in detail from many different viewpoints. According to Pegram (1999), case study research is a single, in-depth investigation. Yin (1984) has defined the case study method as ‘an empirical inquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used’. According to Tellis (1997), case studies are designed to bring out the details from the viewpoint of participants by using multiple sources of data. In the opinion of Zainal (2007), case studies are considered useful in research as they enable researchers to examine data at the micro-level. Sroka and Silic (n.d.) found the case studies to be very solid and widely used method by researchers.

Validation of the developed model was done in two different SI manufacturing units. The selection was done in such a way that both the plants differ in many aspects such as production capacity, production method, year of establishment, number of employees, location, ownership, etc.

4.1. Company A (Case study – I)

The plant is equipped with state-of-the-art machineries and the latest technology, making the plant one of the best in India. The usage of most advanced technology helps in
keeping emission low and optimize every process in the plants to be energy efficient, thus making the product eco-friendly. The company has pioneered the industry with two induction furnaces of 40 metric tons each along with a common four-strand castor which produces high-quality steel billets. The same is rolled in the most advanced rolling mills to produce TMT bars. With world’s largest medium frequency induction melting furnace at its steel plant which is one of the large steel manufacturing units with the capacity to produce .5 million tone steel per annum.

4.1.1. Quality policy
The company has always strived to produce the finest steel in the world. The committed excellence of company in delivering quality products ensures that the integrated steel plant delivers the highest quality steel. The consistent mechanical and chemical properties of steel are attributed to the usage of high-quality virgin steel that is rolled with superior technology. Stringent quality control at every step makes sure that each product comes out with a stamp of consistency. Company adheres to extremely stringent norms to ensure that the higher quality steel reaches the end users. The fully equipped labs with some of the most ultra modern testing and constant upgradation and research make the company best in its class. The company is certified for international quality standard ISO 9001:2008 and ISO 9001:14000 from JNS-ANZ Australia. The company is highly conscious about maintaining the high quality of its product always.

4.2. Company B (Case study – II)
The plant of Company B has three different units in the same premises. SI is produced in 4 kilns of 100 TPD capacities each. The produced SI is supplied as raw material to steel melting shop (SMS) in the same premises for billet making. The waste heat, along with coal is used for power generation. Thus, the three units are:

(1) DRI unit to produce SI
(2) SMS to produce billets
(3) Power plant to produce electricity

4.2.1. Quality policy
The basic principle of the company is, ‘there is no survival in long term without quality and services.’

4.3. Data analysis
In order to evaluate the companies’ TQM implementation practices and organizational performance, an instrument was prepared as given in Appendix 1. The instrument was administered to evaluate the current situation of TQM implementation and performance. The responses were collected from employees of the plant having different designations and different experiences. The evaluation results are presented in subsequent sections which are translated into score according to scoring methods. It also highlights the extent of relationship between various TQM implementation practices and overall performance.
4.3.1. Reliability of research instrument

The data received from the respondents of Company A as well as from Company B were analyzed for the reliability of research instrument using the software SPSS V 20. The Cronbach’s Alpha was found much above .7, indicating the reliability of instrument. Thus, it permits the further analysis of data (Table 6).

4.3.2. Assessment of company

The responses in the form of data were analyzed, mean of each item was estimated and items were grouped as respective factors. Further, grand mean of all factors were obtained. The mean of responses were proportionally marked in consultation with the experts. Number ‘1’ indicates that the organization is extremely weak in the practice and number ‘8’ indicates that the organization is extremely strong in the practice. During the process of assessment, the strength and weaknesses of the items of the respective factors were pointed out. Score above and below indicates strong and weak items, respectively. If the company is neither strong nor weak in the particular item, it is indicated as ‘Average’. It is relative judgment. Table 7 explains the marking scheme and grading scheme. Based on the total score of factors, the overall grading criterion was decided. The total score is indicated as \( X \).

Table 8 gives the assessment result after detailed analysis of the degree of emphasis of TQM implementation.

Based on above analysis, overall grade of the company for emphasis of TQM implementation and its impact on organizational performance was estimated as follows: (Table 9).

Thus, by using the instrument developed for case study, the degree of emphasis of TQM implementation and its impact on organizational performance was measured. The overall grade achieved as per grading criteria is ‘A’. Through the assessment of the companies’ quality management practices and overall business performance, most of the established relationship between implementation factors and the performance measures of the companies found to be strong to very strong. Two relations such as Top Management Commitment with Productivity and Quality assurance with Customer Satisfaction

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**Table 6. Reliability analysis of instrument.**

| Company  | Cronbach’s alpha |
|----------|------------------|
| Company A | .916             |
| Company B | .946             |

**Table 7. Mean and proportionate score and grading criteria.**

| Mean (response) | Score (strength) | Total score range | Grading |
|-----------------|------------------|-------------------|---------|
| 1.00–1.50       | 1 (Extremely weak) | \( X > 90\% \)    | A⁺      |
| 1.51–2.00       | 2 (Very weak)     | 80\% < \( X < 90\% \) | A       |
| 2.01–2.50       | 3 (Weak)          | 70\% < \( X < 80\% \) | B       |
| 2.51–3.00       | 4 (Average)       | 60\% < \( X < 70\% \) | C       |
| 3.01–3.50       | 5 (Above average) | 50\% < \( X < 60\% \) | D       |
| 3.51–4.00       | 6 (Strong)        | \( X < 50\% \)    | E       |
| 4.01–4.50       | 7 (Very strong)   |                   |         |
| 4.51–5.00       | 8 (Extremely strong) |                  |         |
are found extremely strong. Thus, company is doing well on the front of quality–productivity improvement. This has also validated the instrument used for case study.

4.3.3. Impact of quality practices on the organizational performance

As a result of competitiveness and to strive for better performance, the company has implemented various performance improvement approaches. Many steps have been taken by the company during past to enhance overall performance. The aim of the organization is to achieve better result than the past.

4.3.3.1. TQM implementation. Companies have taken many initiatives for the implementation of QMS for the quality–productivity improvement.

(1) Process management: every care is taken for the process management at both the companies. All departments are involved in quality improvement; there are robust feedback mechanisms; all employees audit the process regularly; there are faster adoptions of new technology for continuous improvement; automation is promoted in production; employees’ suggestions are considered favorably; the process is monitored continuously for improvement; R&D and innovation in the product development are promoted; employees are motivated for QMS implementation.

(2) Top management commitment: top management of both the companies are committed in delivering quality products through quality practices. They have clear vision, mission, and strategic direction. Top management is able to take the responsibility for continuous quality improvement. Adequate budgetary allocations are made for quality improvement initiatives. Constructive efforts of
employees are recognized. Congenial work environment is provided along with fair compensation package to the employees.

(3) **Employee involvement**: both the companies put the efforts for capacity building of employees. Innovation in the work is always encouraged. Good coordination

| Table 10. Mean and F-value of ANOVA for Company – A. |
|------------------------------------------------------|
| 1-Productivity | 2-Business results | 3-Employee satisfaction | 4-Time dimension | 5-Customer satisfaction | 6-Quality performance |
|----------------|---------------------|-------------------------|-----------------|------------------------|-----------------------|
| 1-Process management | 4.67 (3.10) | 3.85 (1.308) | 3.81 (2.603) | 4.15 (1.219) | 4.15 (0.579) | 4.18 (0.441) |
| 2-Top management commitment | 4.59 (.691) | 4.11 (2.639) | 3.81 (2.63) | 4.00 (1.570) | 3.70 (0.654) | 4.04 (0.873) |
| 3-Employee involvement | 4.26 (1.149) | 3.96 (1.503) | 4.11 (1.484) | 3.89 (4.191)* | 3.59 (2.634) | 4.00 (1.549) |
| 4-Organization culture | 4.26 (3.465)* | 4.07 (1.080) | 3.85 (2.365) | 4.07 (1.020) | 4.11 (1.318) | 4.22 (2.648) |
| 5-Effective networking | 4.26 (2.21) | 4.44 (0.242) | 3.89 (2.730) | 3.74 (2.147) | 4.04 (2.648) | 4.04 (2.648) |
| 6-Quality assurance | 4.26 (9.93) | 3.96 (2.242) | 4.15 (2.388) | 4.18 (1.279) | 4.55 (1.096) | 4.48 (1.376) |
| 7-Competitive assessment | 4.33 (.135) | 4.3 (2.097) | 3.18 (2.233) | 3.67 (2.76) | 3.89 (2.233) | 4.18 (2.33) |
| 8-Training | 4.41 (5.201)** | 4.15 (7.653)** | 4.30 (5.84) | 4.26 (2.109) | 4.00 (2.65) | 4.48 (2.886) |

*Indicates one tailed significance.
**Indicates two tailed significance.

| Table 11. Mean and F-value of ANOVA for Company – B. |
|------------------------------------------------------|
| 1-Productivity improvement | 2-Business results | 3-Employee satisfaction | 4-Time dimension | 5-Customer satisfaction | 6-Quality performance |
|-----------------------------|---------------------|-------------------------|-----------------|------------------------|-----------------------|
| 1-Process management | 4.06 (.954) | 4.18 (1.044) | 3.82 (1.557) | 3.53 (1.566) | 4.41 (0.684) | 4.47 (0.366) |
| 2-Top management commitment | 4.29 (.889)** | 4.06 (1.95) | 3.94 (2.75) | 3.65 (2.464) | 4.35 (0.765) | 4.35 (0.131) |
| 3-Employee involvement | 4.35 (3.524)* | 4.06 (2.079) | 3.41 (.777) | 3.94 (0.908) | 4.00 (2.569) | 4.41 (3.704)* |
| 4-Organization culture | 4.23 (1.753) | 3.94 (.153) | 3.94 (.430) | 3.88 (1.058) | 3.94 (3.366) | 4.12 (2.737) |
| 5-Effective networking | 4.29 (1.842) | 4.18 (.1488) | 3.88 (.698) | 3.76 (.801) | 3.88 (5.134)* | 3.82 (8.125)** |
| 6-Quality assurance | 4.00 (1.603) | 4.06 (1.858) | 3.70 (.535) | 3.29 (.592) | 4.06 (0.384) | 4.06 (1.744) |
| 7-Competitive assessment | 3.94 (.369) | 3.76 (.398) | 3.59 (.040) | 3.59 (1.034) | 3.70 (.986) | 3.65 (1.463) |
| 8-Training | 4.47 (.566) | 4.23 (.3526)* | 4.00 (2.208) | 3.94 (1.256) | 3.70 (3.183) | 4.06 (1.824) |

*Indicates one tailed significance.
**Indicates two tailed significance.
and cooperation is maintained in the plant. All these help in more and more involvement of employees.  

(4) *Organization culture*: companies have well-defined organizational structure and governance system. Through the well-defined rules, regulations, and operating procedures and team spirit among the employees, companies get better performance.  

(5) *Effective networking*: it is observed that effective networking has been managed by the companies through various ways such as honest and two-way communication between management and employees, regular monitoring of internal and external customer satisfaction; providing technical guidance to suppliers etc.  

(6) *Quality assurance*: quality is assured and improved continuously through various ways. Every effort is directed towards the achievement of better and better quality through integration of prevention and correction in production process.

*Figure 4. Graphical representation of relations for Company A.*
(7) Competitive assessment: companies maintain the internal supply chain and manages the relationship with suppliers. Based on the current performance, the goal is set for future.

(8) Training: the employees are given on job training to understand the practical aspects of SI manufacturing. Top management of both the companies provides guidance and ensures the effectiveness of training.

Thus, by using the instrument developed for case study, the degree of emphasis of TQM implementation and its impact on organizational performance was measured. The overall grade achieved as per grading criteria is ‘A’. Through the assessment of the companies’ quality management practices and overall business performance, most of the established relationship between implementation factors and the performance measures
of the company found to be strong to very strong. One relation i.e. Training with Time Dimension is found extremely strong, while two relations i.e. Employee Involvement with Employee Satisfaction and Quality Assurance with Time Dimension found above average. Thus, company is doing well on the front of quality–productivity improvement. This has also validated the instrument used for case study.

5. Result
For the validation of the models developed for coal-based SI industry in India as given in section 3 and to find out the significance of developed relations, the collected data for company A and Company B was analyzed using the software SPSS V 20 to carry out ANOVA through mean and $F$-value. ANOVA is useful to identify the differences between the perceptions of employees based on some parameter. Tables 10 and 11 show the mean and $F$-value of ANOVA for Company A and Company B, respectively.

The Figure 4 shows similarity of relations with the earlier developed relations for Company A.

The Figure 5 shows similarity of relations with the earlier developed relations for Company B.

6. Conclusion
From the data given in Tables 10 and 11 and subsequently drawn into Figures 4 and 5, it is observed that there are many relations similar to developed model for coal-based SI industry in India, shown in Figure 3.

The relations those are observed similar to the earlier developed relations are:

(1) Process management and productivity improvement
(2) Process management and business result
(3) Process management and employee satisfaction
(4) Process management and time dimension
(5) Process management and quality performance
(6) Top management commitment and business results
(7) Top management commitment and customer satisfaction
(8) Employee involvement and productivity improvement
(9) Employee involvement and employee satisfaction
(10) Organization culture and productivity improvement
(11) Organization culture and business results
(12) Effective networking and productivity improvement
(13) Effective networking and business results
(14) Quality assurance and productivity improvement
(15) Quality assurance and quality performance
(16) Competitive assessment and quality performance
(17) Training and productivity improvement

In both the companies, some relationships have been added to earlier relations as follows –

(18) Process management and customer satisfaction
(19) Top management commitment and time dimension
(20) Organization culture and time dimension
(21) Organization culture and customer satisfaction
(22) Organization culture and quality performance
(23) Effective networking and employee satisfaction
(24) Effective networking and time dimension
(25) Effective networking and quality performance
(26) Quality assurance and business results
(27) Quality assurance and employee satisfaction
(28) Quality assurance and customer satisfaction
(29) Competitive assessment and productivity improvement
(30) Competitive assessment and business results
(31) Competitive assessment and employee satisfaction
(32) Competitive assessment and customer satisfaction
(33) Training and employee satisfaction
(34) Training and time dimension
(35) Training and customer satisfaction
(36) Training and quality performance

Company A does not reject any relation, while only two relations are rejected by Company B. Since almost all the relations indicated by model developed for coal-based SI industry are endorsed by both case studies, both the case studies validate the model developed for coal-based SI industry in India.

7. Discussion
Validation of the model, developed for coal-based SI industry in India has been done through the two case studies. Both the plants have different capacity, location, manufacturing process, and number of employees. This has enabled to get the quality–productivity status from the SI manufacturers of different nature. It is found that significant relationships exist between implementation factors and performance measures of companies. It was noticed that various performance indicators have remarkable improvement over the years. The companies have achieved both tangible and intangible benefits by practicing quality management.

8. Future scope
The validated model may be implemented to all SI plants in India for quality–productivity improvement. Ultimately, it will help improve the bottom line of the company – the very essence of any business. The concept can also be expanded to other fields.

Disclosure statement
No potential conflict of interest was reported by the author(s).

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Appendix 1

Questionnaire for case study validation

Identification of critical success factors and performance measures for sponge iron industry – model validation (The information provided here will be kept strictly confidential).

Name of the respondent: ____________________________
Qualification: ____________________________
E-mail: ____________________________
Mobile No.: ____________________________
Industry name & address: ____________________________

Critical success factors and performance measurement factors

Based on the analysis of responses, eight CSFs and six PMFs were derived. More focus on CSFs (also called as input factors, TQM factors or significant factors) will lead to the improvement in PMFs (also called as output factors). Detailed descriptions of factors are –

(A) Critical success factors

1. Process management includes all those attributes that suggest the need of process management in sponge iron industry, such as involvement of all departments in quality improvement processes; regular measurement and monitoring of quality cost; consideration of employee’s suggestions/feedback; robust feedback mechanism; regular process auditing by all employees; cross-functional team participation; collective responsibility; training programs for quality techniques; advanced statistical techniques training programs; continuous process monitoring and improvement; data-driven process improvement; faster adoption of new technology for continuous improvement; promoting R&D and innovation for product development; promoting automation in production; conducive environment for implementation of QMS; and motivation to the employees for implementing QMS etc.

2. Top management commitment signifies an important role of top management’s clarity of vision, mission, and strategic direction; top management’s ability to take responsibility for continuous quality improvement; adequate budgetary allocation for quality improvement initiatives; recognition of constructive efforts of employees by management; management’s commitment for providing good work environment; fair compensation package to employees; and congenial work environment.

3. Employee involvement has loading of regular mapping and monitoring of employee’s skills and competencies; capacity building of employees; use of benchmarking for process improvement; encouraging innovation; good coordination and cooperation; and measurement of employee commitment levels.

4. Organization culture accounts for team spirit; well-defined organizational structure and governance system; well-defined rules, regulations and operating procedures.

5. Effective networking is based on the important role of honest and two-way communication between management and employees; fulfillment of legal, ethical, and social responsibilities by the company; establishment of management information system; providing technical guidance to suppliers; selection of suppliers on the basis of raw material quality; regular monitoring of customer satisfaction; standardization of customer care systems; customer relationship management.

6. Quality assurance is an indicator of use of statistical process control for process management; integration of prevention and correction in production process.
(7) Competitive assessment is based on the attributes such as goal setting on the basis of current performance; finalizing strategy after SWOT analysis; supplier relationship management; internal supply chain.

(8) Training includes communication skill improvement training programs; leadership development training programs.

(B) Performance measurement factors

1. Productivity improvement: has loading of high capital productivity; high productivity of each employee; high productivity of assets; equipment availability for longer duration; optimum human resource utilization; lower product development time; low machine line downtime; low supplier lead time; etc.

2. Business result: includes high return on investment; top-line growth; sustainable increase in market share; bottom line growth; high processes efficiency; less variation in process; higher process accuracy rate.

3. Employee satisfaction: accounts for higher value addition per employee; high job satisfaction of employees; employee involvement; better environmental compliance; better safety of employees; positive change in corporate culture; better quality of work life.

4. Time dimension: signify an important role of reduced material procurement time; low-order process time; low process through time; high inventory turnover (material productivity); high flexibility in operations / system; etc.

5. Customer’s satisfaction: is based on customer retention; low customer complaints; higher customer satisfaction (value for the money spent); etc.

6. Quality performance: accounts for less number of defects in the finished product; less rework and waste; optimum inventory utilization; low cost of quality; etc.

Relationship between critical success factors and performance measures

Based on your experience, please rate the importance of following elements in achieving successful implementation of TQM model in sponge iron industry.

| S. No. | Attribute/variables                                                                 | Very low IMP 1 | Low IMP 2 | Med IMP 3 | High IMP 4 | Very high IMP 5 |
|--------|-------------------------------------------------------------------------------------|----------------|-----------|-----------|------------|----------------|
| 1.     | Process management leads to improvement in productivity                             |                |           |           |            |                |
| 2.     | Process management leads to improvement in business results                         |                |           |           |            |                |
| 3.     | Process management leads to improvement in employee satisfaction                   |                |           |           |            |                |
| 4.     | Process management leads to improvement in time dimension                           |                |           |           |            |                |
| 5.     | Process management leads to improvement in customer’s satisfaction                  |                |           |           |            |                |
| 6.     | Process management leads to improvement in quality performance                     |                |           |           |            |                |
| 7.     | Top management commitment leads to improvement in productivity                     |                |           |           |            |                |

(Continued)
| S. No. | Attribute/variables                                                      | Very low IMP 1 | Low IMP 2 | Med IMP 3 | High IMP 4 | Very high IMP 5 |
|-------|------------------------------------------------------------------------|----------------|-----------|-----------|------------|-----------------|
| 8.    | Top management commitment leads to improvement in business results     |                |           |           |            |                 |
| 9.    | Top management commitment leads to improvement in employee satisfaction |                |           |           |            |                 |
| 10.   | Top management commitment leads to improvement in time dimension        |                |           |           |            |                 |
| 11.   | Top Management Commitment leads to improvement in Customer’s Satisfaction |                |           |           |            |                 |
| 12.   | Top management commitment leads to improvement in quality performance   |                |           |           |            |                 |
| 13.   | Employees involvement leads to improvement in productivity             |                |           |           |            |                 |
| 14.   | Employee involvement leads to improvement in business results           |                |           |           |            |                 |
| 15.   | Employee involvement leads to improvement in employee satisfaction      |                |           |           |            |                 |
| 16.   | Employee involvement leads to improvement in time dimension             |                |           |           |            |                 |
| 17.   | Employee involvement leads to improvement in customer’s satisfaction    |                |           |           |            |                 |
| 18.   | Employee involvement leads to improvement in quality performance        |                |           |           |            |                 |
| 19.   | Organization culture leads to improvement in productivity              |                |           |           |            |                 |
| 20.   | Organization culture leads to improvement in business results           |                |           |           |            |                 |
| 21.   | Organization culture leads to improvement in employee satisfaction      |                |           |           |            |                 |
| 22.   | Organization culture leads to improvement in time dimension             |                |           |           |            |                 |
| 23.   | Organization culture leads to improvement in customer’s satisfaction    |                |           |           |            |                 |
| 24.   | Organization culture leads to improvement in quality performance        |                |           |           |            |                 |
| 25.   | Effective networking leads to improvement in productivity              |                |           |           |            |                 |
| 26.   | Effective networking leads to improvement in business results           |                |           |           |            |                 |
| 27.   | Effective networking leads to improvement in employee satisfaction      |                |           |           |            |                 |
| 28.   | Effective networking leads to improvement in time dimension             |                |           |           |            |                 |
| 29.   | Effective networking leads to improvement in customer’s satisfaction    |                |           |           |            |                 |
| 30.   | Effective networking leads to improvement in quality performance        |                |           |           |            |                 |
| 31.   | Quality assurance leads to improvement in productivity                 |                |           |           |            |                 |
| 32.   | Quality assurance leads to improvement in business results              |                |           |           |            |                 |

(Continued)
| S. No. | Attribute/variables                                      | Very low IMP | Low IMP | Med IMP | High IMP | Very high IMP |
|-------|---------------------------------------------------------|--------------|---------|---------|----------|---------------|
| 33.   | Quality assurance leads to improvement in employee satisfaction | □            | □       | □       | □        | □             |
| 34.   | Quality assurance leads to improvement in time dimension | □            | □       | □       | □        | □             |
| 35.   | Quality assurance leads to improvement in customer’s satisfaction | □            | □       | □       | □        | □             |
| 36.   | Quality assurance leads to improvement in quality performance | □            | □       | □       | □        | □             |
| 37.   | Competitive assessment leads to improvement in productivity | □            | □       | □       | □        | □             |
| 38.   | Competitive assessment leads to improvement in business results | □            | □       | □       | □        | □             |
| 39.   | Competitive assessment leads to improvement in employee satisfaction | □            | □       | □       | □        | □             |
| 40.   | Competitive assessment leads to improvement in time dimension | □            | □       | □       | □        | □             |
| 41.   | Competitive assessment leads to improvement in customer’s satisfaction | □            | □       | □       | □        | □             |
| 42.   | Competitive assessment leads to improvement in quality performance | □            | □       | □       | □        | □             |
| 43.   | Training leads to improvement in productivity            | □            | □       | □       | □        | □             |
| 44.   | Training leads to improvement in business results         | □            | □       | □       | □        | □             |
| 45.   | Training leads to improvement in employee satisfaction    | □            | □       | □       | □        | □             |
| 46.   | Training leads to improvement in time dimension           | □            | □       | □       | □        | □             |
| 47.   | Training leads to improvement in customer’s satisfaction  | □            | □       | □       | □        | □             |
| 48.   | Training leads to improvement in quality performance      | □            | □       | □       | □        | □             |
1. In your opinion, what are the areas in Sponge Iron Industry which require immediate attention for quality & productivity improvement?

Ans:-

2. What solutions you suggest for improvement in quality & productivity in Sponge Iron Industry?

Ans:-

3. Kindly suggest, Critical Factors, that you feel are important, but not covered in my study.

Ans:-

4. How important is Industry – Institute partnership for growth of both?

Ans :-

5. Any other aspects / issues, you would like to mention for improvement / excellence of Sponge Iron Industry.

Ans:-