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Implementation of Lean in Continuous Industry: A Case Study (Steel Industry)

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Abstract
The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment, and to evaluate their benefits on a specific application instance. Although the process and discrete industry share several common characteristics, there are areas where they are very different. This research attempts to identify commonalities between discrete and continuous manufacturing where lean techniques from the discrete side are directly applicable.
***Key* words:** Lean, lean tool, Discrete manufacturing, Competitiveness, Sources of Competitiveness.

I. Introduction

This research addresses the application of lean manufacturing concepts to the continuous production/ process sector with a focus on the steel industry. Toyota Motor Company in Japan pioneered the concept of the Toyota Production System, or what is known today in the US as "Lean Manufacturing." The basic idea behind the system is eliminating waste. Waste is defined as anything that does not add value to the end product from the customer's perspective. . Lean is to manufacture only what is needed by the customer, when it is needed and in the quantities ordered. Tools including just in time, cellular manufacturing, total productive maintenance, single-minute exchange of dies, and production smoothing have been widely used in discrete parts manufacturing sectors such as automotive, electronics and appliance manufacturing.

II. Problem Statement

Lean tools and techniques of lean manufacturing have been widely used in the discrete industry but applications of lean manufacturing to the continuous process industry have been far fewer. this is because such industries are inherently more efficient and present relatively less need for such improvement activities. Managers have also been hesitant to adopt lean manufacturing tools and techniques to the continuous process industry because of reasons such as high volume and low variety products, large inflexible machines, and the long setup times that characterize the process industry. As an example, it is difficult to use the cellular manufacturing concept in a process facility due to the fact that equipment is large and not easy to move. While it seems that some lean manufacturing tools are difficult to adapt in the process industry. For example, Cook and Rogowski (1996) and Billesbach (1994) used just-in-time concepts at a process facility; nobody has systematically investigated how to apply lean tools and techniques to a continuous process facility due to the differences exhibited between the two manufacturing environments.

III. Research Approach

The initial step in this research is to systematically study and define the history of the lean manufacturing concept and its different tools and techniques. This will be followed by a literature review of the process industry and a study of the findings regarding applications of lean concepts to continuous manufacturing, and the steel industry in particular. . The next step is to develop taxonomy of the continuous process industry with respect to its product/process characteristics and the relative balance of discrete and continuous operations. This taxonomy is used to contrast the process industry and to characterize the process industry into distinguishable groups. Next, this taxonomy is used to examine and identify specific lean manufacturing tools and techniques that could be applicable. To study the effect of lean tools in the process sector the steel industry is used to illustrate the procedures of implementing lean tools at a process facility. The future state map is developed for a system with lean tools applied to it.

Discrete vs. Continuous Manufacturing Systems

Manufacturing systems are classified into two major classes; discrete manufacturing and continuous manufacturing (also referred to as the process industry). Discrete manufacturing refers to making discrete products such as an engine, an automobile, a drive shaft, a coffee maker, or a

washing machine. On the other hand, continuous manufacturing includes making products that are measured or metered rather than being counted. Examples include paint, steel, textile, flat glass, resin, oil, and flour (Needy and Bidanda, 2001).

Case Study:

4.3.1 Study Area (X Steel Ltd.)

X Steel Ltd produces several products that are used primarily in appliance manufacturing. The annealed product type. X Steel Ltd produces three types of the annealed product: open coil annealed, hydrogen batch annealed and continuous annealed.

The objectives of the industry are:

1. To train technical and non-technical personnel.
2. To Reduces Production cycle time.
3. To reduces Product delivery lead-time.
4. To conduct research in the respective fields.

IV. Method of Data Collection

A total of 100 questionnaires each were prepared and randomly administered among management, employees and vendors.

One of the procedures used for data collection in this research work was through the use of questionnaires since it is an effective and systematic way of asking questions under scientific control. Interviews were conducted with both top management staff to elicit information about the efforts in achieving TQM through HRM. In other words, almost all individual characteristics as well as the respective subgroups were covered by the sample. The interviews were performed to gain a deeper knowledge of the results received by the questionnaire respondents. The interviews were structured in order to ensure the objectivity of the research, and open-ended questions were used. Quantitative and qualitative aspects may also be combined in the same study.

Various Factors of Lean Manufacturing Which Effect the Organization

Business Services: A service that is clearly identifiable by business representatives and has a clear line to the business value chain, interfacing closely with explicit business processes. In this lean manufacturing process used in X steel ltd. there are three types of Business Service are explain one is Professional service second is Research and Development Service and third is Other Business service. Business Service means Service related to all area of the manufacturing known as Service Incidental to Manufacturing, Technical testing and analysis service, market research and public service etc. In this questionnaire there are four sub parts of the Professional Service as follows (1) Engineering Service (2) Integrated Engineering Service (3) Accounting and Auditing Service (4) Taxation Service. See table 1

(TABLE 1) **Business Services**

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
1.1. Professional Services					
1. I. Engineering Services	4	6	5	7	8
1. II. Integrated Engineering Services	7	9	9	8	9
1. III. Accounting & Auditing Services	6	8	5	9	9
1. IV. Taxation Services	8	8	7	8	8
Total	25	31	26	32	34
1.2. Research and Development Services					
2. I. R & D Services	2	3	2	3	3
2. II. Interdisciplinary R&D Services	3	4	3	4	5
Total	5	7	5	7	8
1.3. Other Business Services					
3. I. Service incidental to Manufacturing	6	7	5	8	9
3. II. Technical testing and analysis service	7	8	6	9	10
3. III. Market research and public opinion polling Services	5	6	4	7	8

3. IV. Advertising Services	2	3	2	3	3
3. V. Services related to Manufacturing Consulting	4	6	3	5	7
3. VI. Management Consulting Services	3	4	3	6	8
3. VII. Building-Clearing Services	6	7	7	8	9
3. VIII. Maintenance and repair of equipment	3	5	4	6	8
3. IX. Supply Services of Personnel	4	5	4	6	7
3.X. Packaging Services	7	8	7	8	9
Total	47	58	45	66	78
Total	**77**	**96**	**76**	**105**	**120**

Communication Services: Management directly and honestly communicates priorities, strategies and status to all levels of the work force. . Cell design puts material, tools, and equipment for the comfort and ease of use by the cell's operators. Each cell has good physical facilities for communications, e.g., meeting areas and communications boards. in this project we taken as a six sub group of Telecommunication services name as Voice Telephone service, Electronic Mail, Voice Mail, On-line information and data base retrieval, Enhanced/ value- added facsimile services, incl. store and forward. Store and receives. And on-line information/ data processing. See table 2

(TABLE 2) Communication Services

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
2.1. Telecommunication Services					
1.I. Voice Telephone Services	6	7	6	8	9
1. II. Electronic Mail	5	7	7	9	10
1. III. Voice Mail	0	0	0	0	0
1. IV. On-line information and data base retrieval	7	8	6	8	9
1.V.enhanced/Value-added facsimile services,incl.store and forward, store and retrieve	4	5	4	6	7
1. VI. On-line information / Data processing(incl.transaction processing)	5	4	4	5	6
Total	**27**	**31**	**27**	**36**	**41**

Distribution Services: Distribution service is defined as in terms of manufacturing company the supply of any product is of consumer by help of these channels. These channels are known as Commission agent's service, Wholesale trade Service and Retailing service. See table 3

(TABLE3) Distribution Services

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
I. Commission agent's Services	2	3	3	2	3

II. Wholesale trade Services	1	1	1	3	4
III. Retailing Services	0	0	0	0	0
Total	3	4	4	5	7

Educational Services:

In this lean manufacturing system the education is play a very important role. In this education article the three types of schooling is very important name as (1) primary Education Service (2) Secondary Education Service and (3) Higher Education Service. In primary education service the first step of schooling system. In this service the education nursery to fifth class. In Secondary Education Service is the second step of the education system in this type of system the education must be 6th class to 10th class. And last step is Higher education service in this type of system above of 10th class education system. See table 4

(TABLE 4) Educational Services

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
I. Primary Education Service	4	5	5	8	9
II. Secondary Education Services	6	7	7	9	9
III. Higher Education Services	7	8	7	8	9
Total	17	20	19	25	27

Environmental services : The various combinations of scientific, technical, and advisory activities (including modification processes, i.e., the influence of manmade and natural factors) required to acquire, produce, and supply information on the past, present, and future states of space, atmospheric, and disposal service and sanitation and similar service of the manufacturing process. In this lean manufacturing concept the environmental service is a very important part of steel plant. Because in steel plant the blast furnace is used so emission of smoke is very high. In this project we taken a there sub parts of analysis name as

(1) coolant Services
(2) Disposal Service
(3) Sanitation and Similar Services. See table 5

(TABLE 5) Environmental services

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
I. Coolant Services	6	7	6	7	8
II. Disposal Services	7	8	7	8	9
III. Sanitation and Similar Services	0	0	0	0	0
Total	**13**	**15**	**13**	**15**	**17**

Financial Services: Financial services are the economic services provided by the finance industry, which encompasses a broad range of organizations that manage money, including credit unions, banks, credit card companies, insurance companies, consumer finance companies, stock brokerages, investment funds and some government sponsored enterprises. Companies usually have two distinct approaches to this type of business. One approach Banking and Other financial service and another is All Insurance and Insurance related Service. See table 6

(TABLE 6) Financial Services

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
6.1. All Insurance and Insurance Related Services					
1.I. Life, Accident and health Insurance Services	6	7	7	8	9
1. II. Non-life Insurance Services	3	4	3	4	5
1. III. Reinsurance and retrocession	0	0	0	0	0
1. IV. Services auxiliary to insurance (Including broking and agency service)	2	3	3	4	4
Total	11	14	13	16	18
6.2. Banking and Other Financial Service					
2.I. Acceptance of deposits and other repayable funds from the public	4	3	2	4	5
2. II. Leading of all types incl. internally, consumer credit, mortgages credit, factoring and financing of commercial transaction	3	2	2	3	4
2. III. Financial leasing	2	3	2	3	3
2. IV. All payment and Money transmission services	6	7	7	8	9
2.V. Guarantees and Commitments	8	8	6	8	9
Total	23	23	19	26	30
Total	34	37	32	42	48

Transport services: Transportation Service Material Transportation is an important activity within the larger system by which materials are moved, stored, and tracked in our commercial infrastructure. The term commonly used for the larger system is logistics, which is concerned with the acquisition, movement, storage, and distribution of materials and products as well as the planning and control of these operations in order to satisfy customer demand. Logistics operations can be divided into two basic categories, external logistics and internal logistics, External logistics is concerned with transportation and related activities that occur outside of facility. In this bhusan steel ltd. We discussed in three types of Transportation service. Name as (1) Rail Transportation service (2) Road Transportation Service. And (3) Service Auxiliary to all modes of Transport. See table 7

(TABLE 7) Transport services:

Years	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
7.1 Rail Transport Service					
1.I Passenger Transportation	0	0	0	0	0
1.II Pushing and towing services	0	0	0	0	0
1.III Freight transportation	0	0	0	0	0
1.IV Supporting Services for rail transport	0	0	0	0	0
Total	0	0	0	0	0
7.2 Road Transport Services					

2.I Passengers Transportation	0	0	0	0	0
2.II Freight transportation	2	3	2	3	3
2.III Rental of Commercial Vehicles with operations	6	5	6	7	7
2.IV Maintenance and repair of road transport equipment	5	6	5	4	6
Total	13	14	13	14	16
7.3 Services auxiliary to all modes of Transport					
3.I. Cargo-handling services	0	0	0	0	0
3. II. Storage and warehouse services	7	8	7	8	9
3. III. Freight transport agency services	3	2	2	4	4
Total	10	10	9	12	13
Total	**23**	**24**	**22**	**26**	**29**

COMPETITIVE INDX TABLE

Factor	**Sub Factor**	**Mean= $\frac{\sum ALL\ FACTORS}{TOTAL\ NO.OF\ FACTORS}$**		**Rank**		**Inverse of Rank(K_i)**		**logK_i**		**Weightage**		**W_i x logK_i**	
year →		**2006-07**	**2010-11**	**2006-07**	**2010-11**	**2006-07**	**2010-11**	**2006-07**	**2010-11**	**2006-07**	**2010-11**	**2006-07**	**2010-11**
1	1→16	4.81	7.50	2	3	6	5	0.778	0.698	+1	+1	0.778	0.698
2	1 →6	4.50	6.83	3	4	5	4	0.698	0.602	+1	+1	0.698	0.602
3	1→ 3	1.00	2.34	7	7	1	1	0.000	0.000	0	-1	0.000	0.000
4	1→ 3	5.66	9.00	1	2	7	6	0.845	0.778	+1	+1	0.845	0.778
5	1→ 3	4.33	5.67	4	5	4	3	0.602	0.477	+1	+1	0.602	0.477
6	1→ 9	3.77	16.00	5	1	3	7	0.477	0.845	0	+1	0.477	0.845
7	1→ 11	2.09	2.64	6	6	2	2	0.301	0.301	-1	-1	-0.301	-0.301
											total	**2.622**	**3.099**

V. Results

Competitive Analysis Method The competitive analysis method is a statement of the business strategy and how it relates to the competition. The purpose of the competitive analysis is to determine the strengths and weaknesses of the competitors within your market, strategies that will provide you with a distinct advantage, the barriers that can be developed in order to prevent competition from entering your market, and any weaknesses that can be exploited within the product development cycle.
To determine just what constitutes a key asset or skill within an industry, David A. Asker in his book, Developing Business Strategies suggests concentrating your efforts in four areas:

1. The reasons behind successful as well as unsuccessful firms
2. Prime customer motivators
3. Major component costs
4. Industry mobility barriers

But in this paper we compare the two years of all without application of lean manufacturing tools (i.e.2006-07) and When Lean tool is applicable (i.e. 2010-11) in X Steel Ltd.

VI. COMPETITIVE INDX

Step by step calculating Competitive index method of our project.

STEP-1 First of all we take factor of the questionnaire. In this project there are seven factor of the questionnaire.

STEP-2 we take a factor of the questionnaire then we take sub factor of this questionnaire. (See table-……)

STEP-3 The third step of competitive index method is finding the mean. In calculating the mean, we taken as formula the ratio between sums of all factor to total no of factors. The mean has been calculated.

STEP-4 In fourth steps we can decide the Ranks. In this ranks the maximum value of the mean we take one rank again the second maximum value of the mean we taken rank is second and so on.

STEP-5 In fifth step we Taken as the Inverse of Rank. This is denoted by Ki. So in this inverse of Rank we take the one Rank is denoted the last rank and second highest rank is denoted by second last rank and so on. See table

STEP-6 in next step we calculate the log of k_i of all factors. We should take all value in percentage (%).

STEP-7 The next step finding the Weightage of all factors. IN this method we take the wattage of this all tools is if the Value of log Ki is more than or equal to 60% then we have taken as positive one (i.e. +1) and if the value of log ki is lies between 40% to 60% we taken as Weightage e is Zero (i.e. 0) and if the value of log ki is less than and equal to 40% then we take as wattage is Negative One (i.e. -1). In other words,

Weightage ≥ 60% ---------- +1

40% to 60 %------ 0

≤40% ---------- -1

STEP-8 in this last step we calculate the value of the product of Weightage and log k_i (i.e. Wi x logK_i).

- To calculate the competitive index method of lean tools the fowling formula is used.

Ci= □ (Wi x log Ki)

Where
Ci= Competitive Index.
Wi = Weightage
Ki = Inverse Rank

- The Theoretically Value of CI is Ci = -3.716 to 3.71

VII. Conclusions

The main goal of this research paper was to develop a general methodology to Tools and Techniques of Lean Manufacturing Steel Industries Analysis by Competitiveness as a specific application instance. The first task of this research was to develop taxonomy of the process industries to further characterize it into distinguishable groups and study how lean tools can be applied. The second task was to develop a survey of the steel industry to examine the current level of lean implementation in the steel sector. From the survey it was found that with steel companies (as with others), the driving force behind implementing lean was cost reduction. Also from the findings of the survey, various companies reported making at least some effort at using a variety of lean tools such as JIT, TQM, TPM, setup reduction, 5S and Competitive Index Method For any process industry that is considering implementing lean manufacturing and that is uncertain of what the potential outcomes might be, simulation can estimate implementation the basic performance measures by comparing the present environment to the proposed lean system. Finally, for those lean tools whose gains cannot be readily quantified, we developed a detailed methodology to implement them at X Steel Ltd. Tools like 5S and Competitive Index Method can have significant impact on X Steel Ltd when implemented, by further helping in elimination of

wastes such as excess inventory, long set up times, and missed shipments.

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