Literature Review and Implications of Standard Work Implementation in Indian Industry- A Case Study

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Abstract: Lean Manufacturing is a concept frequently used by industries in order to reduce costs and for improve quality in manufacturing operations. Lean Manufacturing is a multi-step process to identify and prioritize waste in the form of non-value-adding activities also provides guidelines to reduce or eliminate these wastes. This paper presents implementation of Standard work enabler of Lean Manufacturing in a manufacturing system .In due course of implementation of Standard work enabler of Lean manufacturing; machine-work is separated from operator-work so that machines work independently as much as possible. Standard work combination tables specify exactly how all work is performed. Practical examples of takt time calculation, standardization of work including flow improvement with introduction of U-shaped lines, kaizen, visual management, and lost time analysis are reviewed. In Standard work value chain of one manufacturing cell is mapped in terms of flow of material, deployment of operator and utilization of man and machine is reviewed. Basic information about man and machines are recorded and analyzed hence making Standard work a dominating tool in Lean manufacturing implementation. This paper is an attempt to present real life example of improvement gained through implementation of Standard work enabler.

Purpose – The purpose of this paper is to discuss the measurable Impact of implementation of Standard work enabler of Lean Manufacturing on operational performance.

Keywords: Operational performance, Lean Manufacturing; Lean Manufacturing elements, Lean manufacturing enablers, Standard work.

I INTRODUCTION

Lean Manufacturing got originated in Japan, where it has been in practice since the early 1970's. It was developed and perfected by Taiichi Ohno of Toyota, who is now referred to as the father of Lean Manufacturing. Taiichi Ohno developed this philosophy as a means of meeting customer demands with minimum delays. Thus, in the older days, Lean Manufacturing is used not to reduce manufacturing wastage, but primarily to produce goods so that customer orders are met exactly when they need the products.

Lean Manufacturing is also known as stockless production, since the key behind a successful implementation of Lean Manufacturing is the reduction of inventory levels at the various stations of the production line to the absolute minimum [23]. This requires good coordination between work stations such that every station produces only the exact volume that the next station needs [26]. On the other hand, a station pulls in only the exact volume that it needs from the previous station [21].

The Lean Manufacturing system consists of defining the production flow and setting up the production floor such that the flow of materials as they get manufactured through the line is smooth and unobstructed, thereby reducing material waiting time[14]. This requires that the capacities of the various work stations that the materials pass through are very evenly matched and balanced, such that bottle necks in the production line are eliminated. This set-up ensures that the materials will undergo manufacturing without queuing or stoppage [16]. Lean Manufacturing finds the large amount of applicability in the operations or production flows which are repetitive in nature. An example of this would be an automobile component production or assembly lines, wherein every part undergoes the same production process as the one before it.

Nordin et al explained Lean Manufacturing as a management philosophy aimed at eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time [18]. This is based on the fact that wastes result from any activity that adds cost without adding value to the product, such as transferring of inventories from one place to another or even the mere act of storing them. The aim of Lean Manufacturing, therefore, is to minimize the presence of non-value-adding activities and non-moving inventories in the production line [19]. This will result in shorter throughput times, better on-time delivery performance, higher equipment utilization, lesser space requirement, lower costs, and greater profits.

II LITERATURE REVIEW

Lean Manufacturing is widely regarded as an excellent tool for reducing costs and cycle times, and for improving quality in manufacturing operations. Lean Manufacturing is defined to be an umbrella term for a number of techniques like Production Leveling, Pull System, Kanban system, 5S, Small Lot Production, Setup Time Reduction, Total Preventive Maintenance, Line Balancing, flexible manufacturing and Small-group Activities whose purpose is to improve product quality and cost by eliminating all waste in the production system [32]. Now-a-days shorter product life cycles and increased demands for customization make it difficult to produce different models of products on traditional production lines. Often the best that can be done is to produce them in batch flow systems that have been improved through the incorporation of line flow principles[24]. This is one-piece flow manufacturing. Traditional cells with irregular material flows are replaced by U-shaped production lines. In the U-shaped lines also, problem starts when higher changeover and setup times, unbalanced manufacturing cells, lower effectiveness of the equipments exists. Adoption of continual improvements environment can reduce the problem where setup, changeover times are reduced to negligible, flow is regular and paced by a cycle time and is controlled by pull signals lines are operated as mixed-model lines and each station is able to produce any product.

Lean Manufacturing is implemented to leverage the competency by eliminating waste and non-value adding activities from the manufacturing system [34]. Waste can be in the form of overproduction, defects, excess inventory, inadequate processing, excessive transportation, waiting and unnecessary motion [42]. Lean Manufacturing has potential to improve operational efficiencies, quality and financial performance of the industry [18]. Some out of many objectives of Lean Manufacturing is utilization of equipment and space more efficiently which results in increased output from their existing facilities.

Increasing global competition has forced the business houses and manufacturing organisation to seek new ways to enlarge a competitive edge [12]. Indian manufacturers have also been taking on innovative manufacturing approaches, managerial philosophies, and information technologies to survive in the emerging competitive market. However Indian industries have started its implementation on wide spread observing benefits gained by companies those who implemented Lean manufacturing and gained competitive edges over competitors. Due to its limited implementation full benefit of Lean Manufacturing on performance is not yet to be tested by Indian industry [18]. Before an organization enjoys with the benefits of Lean Manufacturing, it must adopt and practice Lean Manufacturing as an organizational work culture and way of life.

Lean Manufacturing system is justified as a revolutionary tool for improving, manufacturing environment in India with the use of multi attribute decision model of analytical hierarchy process [8]. It is influential in reducing manufacturing lead-time, decreasing throughput time, improving production quality, increasing productivity by highlighting the positive impact of Lean Manufacturing in Indian industries. The result of study has quantified the Lean Manufacturing benefits by showing increased profit margin, quality improvement and reduction in inventory.

Implication of Lean Manufacturing in the purchasing and manufacturing functions has been reviewed by Deshmukh [46]. It has been suggested that suppliers and manufacturing functions must be in assent with design planning and control describing Lean as a compulsory approach for the actions from incoming raw material to the finished goods in order to get improved results.

Dombrowski stated that Lean Manufacturing management needs a high degree of cultural aspects embedded in its development. Transformation in culture of the organisation requires commitment from top management along with work participation in decision making. Training and education to the employees is essential in order to implement and sustain cultural changes [3]. Cultural changes and their presence in background of Lean Manufacturing have been highlighted in Indian industries. It is observed as important initiative for industries to make conscious and deliberate efforts to change the work culture for successful implementation of Lean Manufacturing.

Traditional concepts of quality and customer satisfaction have been challenged in recent years and new benchmarks have been established. Customer choices and perceptions have also been changing continuously. Lean Manufacturing is a philosophy embodying various fundamental concepts that result in a different way of doing business for most organizations. The fundamentals concepts of Lean Manufacturing contain:

- Value is any activity or input that increases the usefulness of the product or service to the customer or reduces the cost to the customer. Any activity or input that does not add value to the product or service is termed as waste and it should be eliminated or reduced.
- Lean Manufacturing is a improvement journey with no end, it rewards on every accomplished step towards its implementation.
- Inventory is a waste. It hides the problems that should be solved rather than covered. Waste can regularly be identified and eliminated by reducing some amount of inventory from the system, correcting the problems that payback, and then removing more inventories.
- The quality, product functionality, delivery schedule and evaluation of performance are to be done by customer and this drives to a customer oriented approach and a trend toward increasingly customized products and demand.
- Increasingly distinguished product line needs to improve flexible manufacturing system, quick response to delivery requests, design changes, and quantity changes, is essential to maintain high quality and low cost.
- Mutual respect and support based on openness and trust should exist among an organization, its employees, its suppliers, and its customers.
- A team effort is required to achieve world class manufacturing capability. Management, staff, and labor must participate. This implies increasing the flexibility, responsibility, and authority provided to the hourly worker.
- The employee who performs a task often is the best source of suggested improvements in the operation. It is important to employ the workers' brains, not merely their hands.

In recent times Lean Manufacturing is gaining acceptance among Indian industry. Many companies in India have applied effort for its implementation and till now there are numerous of successful cases in this regard [39]. Various research papers have published benefits of Lean Manufacturing implementation across India with most essential elements and obstacles faced by industries in its implementation. The Lean Manufacturing approach is an vast term which includes reduction of setup times to achieve smaller production lot sizes, Increased use of single piece flow processes, group technology cells, Increased use of multifunction workers, Increased manufacturing flexibility, Increased use of preventive maintenance, longer term relationships with suppliers, employee involvement programs such as quality circles, suggestion schemes etc. These Lean Manufacturing elements can grow in a continuous improvement environment, which is again responsibility of management with strong will power and requires cooperation from labor unions also. Lean Manufacturing affects all areas of a business; major changes take place in manufacturing management, purchasing, human resources management, and quality management.

Implementation of Lean Manufacturing requires acceptance of the fundamental concepts of Lean Manufacturing system [31]. Focus should always be given on the need of removing waste in all its forms from every activity, which the organisation id performing. A Lean Manufacturing Enterprise will produce greater value for the shareholders, higher levels of customer satisfaction and above all greater employee satisfaction as all play an active role in continuous improvement.

***Lean Manufacturing Elements*:** Different Lean Manufacturing elements are:-

- Buffer stock removal.
- Employee empowerment.
- Error proofing (poka-Yoke)
- Job enlargement.

- Small Group Improvement Activities
- Set up reduction.
- Improve OEE.
- Reduced start up time.
- Reducing low speed losses.
- Quick changeovers
- TPM
- Pull system.
- Good Housekeeping
- Continual quality improvement.
- Total preventive maintenance.
- Process control.
- Multifunctional worker.
- Self-correction of defects.
- Short lead-time.
- Total quality control.
- Reduces work in process inventory.
- Safe working
- Standardization.
- Reduce variability.
- Visibility of area of improvement.
- Flexible manufacturing.
- U-cell or Layout improvement.
- Line Balancing
- Pull System

***Lean Manufacturing Enablers*:** Oehmen et al suggested that for successful implementation of Lean Manufacturing all the elements must be properly understood, measured and implemented. It is very difficult to take care each of these elements individually without any structured approach. The approach adopted here is to divide all the elements in to seven major elements or enablers, which contains some of Lean Manufacturing elements [35]. After proper division of all the Lean Manufacturing elements seven such enablers have been identified. These Seven Enablers of Lean Manufacturing are:

- Kaizen
- Lost Time Analysis
- Standard Work
- 5 S
- Autonomous maintenance
- Value stream mapping
- Visual management

Standard Work as Lean Enabler

The aim of standard work enabler is to decrease process variability by standardizing working during operations and improve productivity and quality by eliminating all types of waste. Standard Work is the process of making standards of doing all activities and formalization them such a way that they are followed by the operators actually during performing his task in operating machines to manufacture a part or to inspect the part after manufacturing.

Standard Work facilitates s the implementation of further improvements by easily integrating them into the actions of all employees. The main objective of Standard Work as Lean Manufacturing enabler is to:

- Work efficiently without wasteful motions
- Sets the standard and allows visibility of areas of improvement.
- Allows labor flexibility, to respond to variations in customer demand.
- Achieving line balancing among all processes in terms of production timing
- Reduces variability between operators and highlights variation inherent to the process.
- Helps to quantify and secure the gains from other improvement activities
- Work efficiently without wasteful motions

III IMPLEMENTATION METHODOLOGY OF STANDARD WORK

For successful implementation of Standard Work people must be considered as most essential element.
Active participation of responsible people for the area will certainly result in successful implementation of Standard Work. Team participation to create and implement Standard Work will make actual difference to the operational performance of the place of work. Demonstrating all the relevant information at the work place is must do activity so as they are reference for the team for adherence. For most important is to make Standard Work instructions easily accessible the arrangement and explain of Standard Work directions must be easily and promptly understandable by all workers. There are four steps to implement Standard Work:

1. Waste removal
2. Documentation of work cycles
3. Apply work standardization
4. Continuous improvements

1. Waste removal

First aim of any waste elimination exercise is to eliminate visible waste from actions of the operators. The first cycle of waste removal must be accomplished before documentation of work cycles; otherwise waste will be formalized into the process. Every action performed by the operator is to be separated as value-added (VA), non value-added (NVA), or waste.

2. Documentation of work cycles

After the initial waste removal cycle, the work area is in a condition to record the work cycles of the process. This. A distinct work cycles must be agreed as there may be some variation of methods between shifts or production teams, and the best solution should always be used. There are three steps in the process of making the Standard work cycles :

i. *Determine the current state*

Current state data is collected with considerations of all activities and involvement of team. Determination of current state involves operation sequences, measurement of actions on time scale and movement of operator during working.
Operator action s must be recorded separating manual work, walking and waiting time.

ii. Determine the improved method of work

Determination of the improved method of work is conducted by the team after optimizing the timing , sequence and work method considering elimination of all forms of waste. The optimal actions must be established to produce a part or run a machine.

iii. Record the Standard Work for implementation

Recording of the Standard Work cycles is a critical activity. The recorded work cycles must be easy to understand, providing clear instructions and must be easy to incorporate any change in future.

3. Apply work standardization

Work cycles generated and documented should contribute to the help of the working group. Work cycles must be understood with clarity and employees should commit to adhere to the standard work cycles.
The full benefits of standard work cycles technique can only be gained if they are fully and effectively implemented and are sustained. Standard Work is a dominating tool to implement Lean Manufacturing to achieve improvements in manufacturing processes if applied properly. Measurable of Standard Work

i. Ascertain that the cycle time meets customer demand.

The time interval available to meet customer demand is called the Takt Time. The target of any manufacturing shop is to keep production cycle time equal to or closely below the Takt time. This will create a waste-free manufacturing capacity. Many manufacturing processes have some basic wastes that do not add value, such as walking between machines and performing quality checks.
Takt Time = Total Available Time per period /Customer Demand per period
The first focus must be on eliminating pure waste such as waiting and reducing the non value-added time used in performing activities that does not add value directly. The authentic cycle time is termed as the time between the completions of succeeding components. This must be applicable for the entire product alternative that pass through the area. The first step when cell balancing is to eliminate waste activities to allow the actual cycle time to meet the target cycle time:

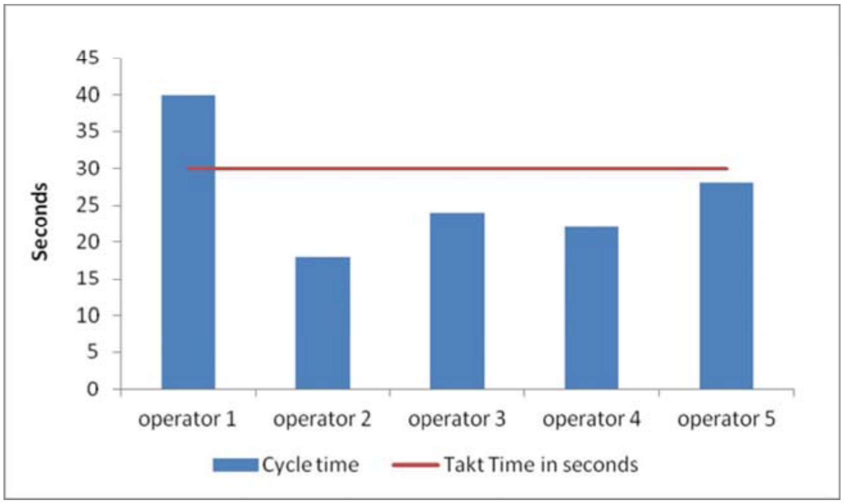


Figure1: Chart showing unbalance manufacturing cell.

In this example, some of the labour content from operator 1 have been moved to operator 2, so that the entire cell meets the target cycle time:

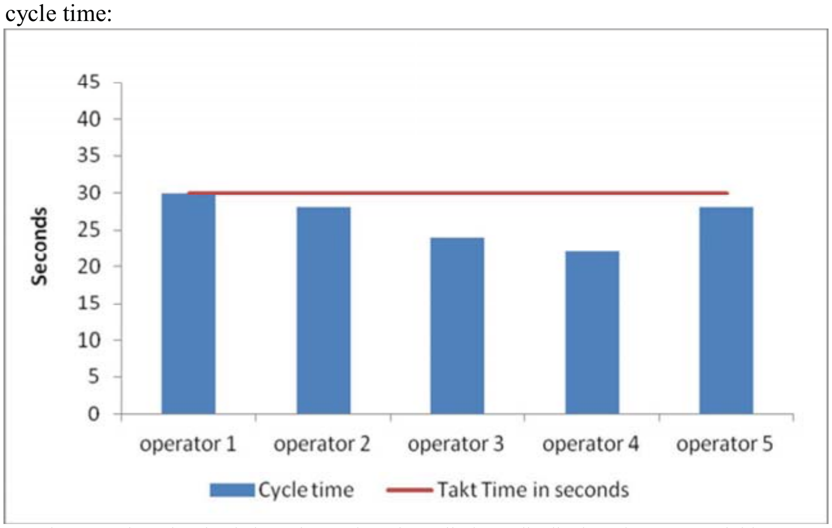


Figure 2: Chart showing balanced manufacturing cell after redistribution of operator activities.

ii. Ascertain that the optimum number of operators is utilized

If a cell is not balanced efficiently there may be possibility to reallocate the content of worker activities or eliminate waste activities and make an operator available for other activities. The purpose must be to achieve the 'optimum' number of operators to meet the customer demand.

Optimum number of operators = (VA + NVA time)/Target cycle time

4. ***Continuous improvements***

Continuous improvements process is iterative and cyclic in nature. These work cycles must be frequently reviewed to implement changes required based on flexibility of demand, compose necessary changes in layout or to include product and process improvements.

IV CASE STUDY

The case study is performed with at a company XYZ, Limited which is an MNC engaged in manufacturing of power transmission automotive parts for passenger cars and light commercial vehicles. The company has implemented

Lean Manufacturing and has gained significant improvement in operational performance with the implementation of Lean Manufacturing. The presented case is an example of Lean enabler Standard work implementation in a manufacturing cell to eliminate waste. Major problems in the studied cell is lower people productivity, high lead time of manufacturing the parts because of batch production, High WIP inventory, resulting around ten times waiting time than actual processing time of the parts. To cope up the problems focus area is to improve the operator productivity using cell balancing techniques

To implement Standard of work of Lean enabler following sub steps were taken for Implementation of standard work

a) Study of layout and material flow
b) Data collection,
c) Analysis of data and decision making,
d) Implementation of actions decided,
e) Monitor and comparison of the results.

a) Study of layout and material flow

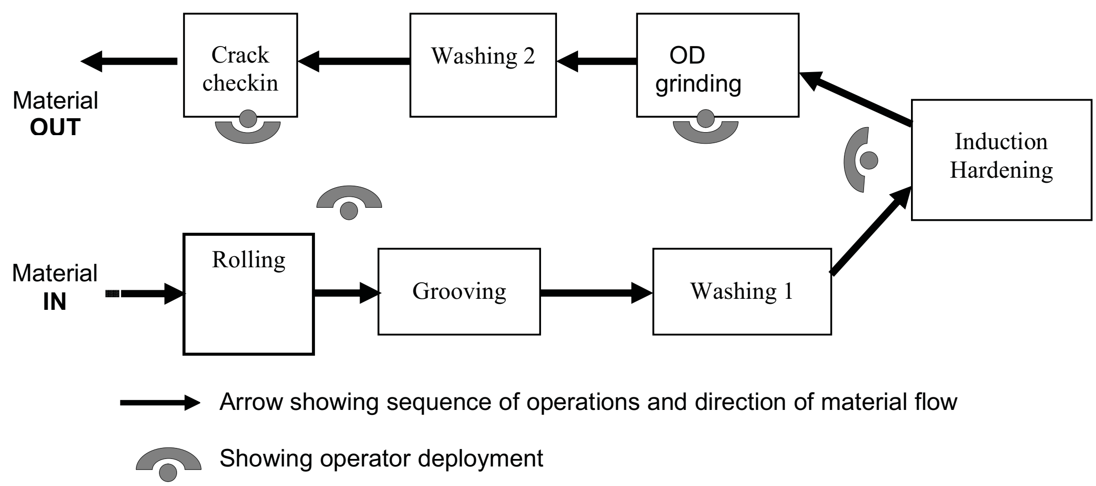


Figure 3: Block diagram showing layout of cell studied

b) Data collection

i) Takt Time Calculation:

Customer Demand (for the month)	= 1720 / per day
Available work Time = 24 Hours	= 1440 min
Less 3 breaks of Lunch @ 30 min. each	= 90 min
Less 6 breaks of Tea @ 10 min. each	= 60 min
Total Available Time	= 1290 min/day
Takt Time = 77400 sec/1720 unit	= 45 seconds
Conclusion of calculation	
Pull demand from cell	= one unit every 45 Seconds.

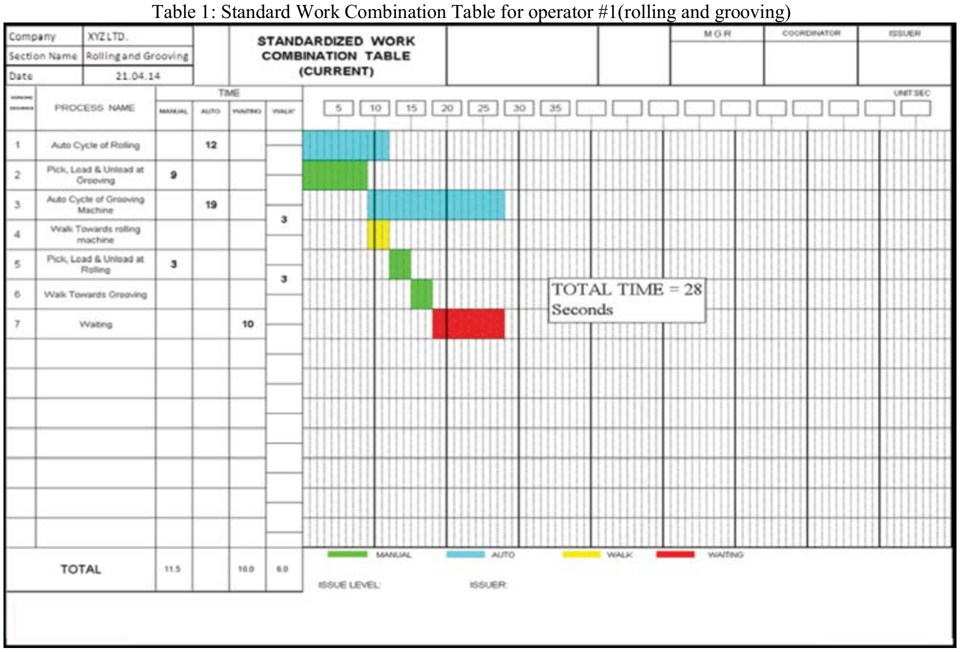
ii) Target Cycle Time Calculation:

Production Requirement	= 1720 / per day
Change over In the month (as per plan)	= 6 nos.
Changeover time	=600 min

Total Changeover time in a month	= 3600 min	
Changeover time per day	= 3600 min/25 working days	
	= 144 mins/day or 8640 Secs/day. 8640/1720 =5.2 Sec	
	= 5.02 Seconds lost to special allowance i.e. changeover time	
Target Cycle time	= 45(Takt) – 5.02(SPA) = 39.98 sec.	

Standard work combination table (SWCT) preparation for analysis work content of each operator in the cell. (SWCT is a table, which is used for data collection pertaining to operator activities with respect to time. In SWCT each activity is recorded to find out the time consumed for each activity and total time by operator for doing all assigned activities. SWCT helps in examining the loading pattern of operator i.e. the time for which operator is working, moving or waiting.)

Table 1: Standard Work Combination Table for operator #1(rolling and grooving)

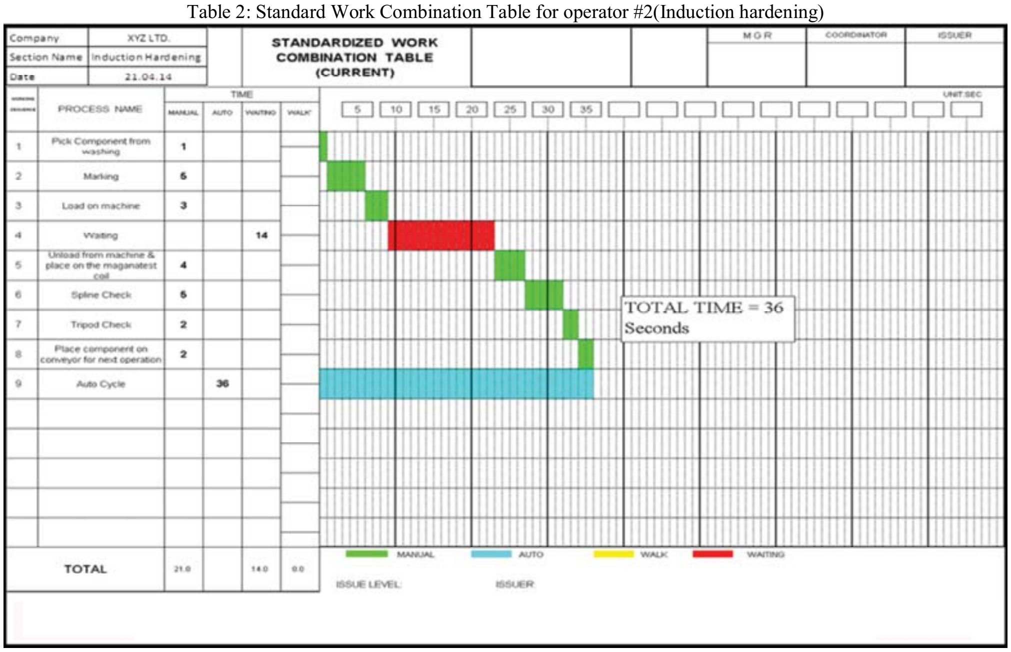


Company: XYZ LTD.
Section Name: Rolling and Grooving
Date: 21.04.14

STANDARDIZED WORK COMBINATION TABLE (CURRENT)

	PROCESS NAME	MANUAL	AUTO	WAITING	WALK
1	Auto Cycle of Rolling		12		
2	Pick, Load & Unload at Grooving	9			
3	Auto Cycle of Grooving Machine		19		
4	Walk Towards rolling machine				3
5	Pick, Load & Unload at Rolling	3			
6	Walk Towards Grooving				3
7	Waiting			10	
	TOTAL	11.5		10.0	6.0

Table 2: Standard Work Combination Table for operator #2(Induction hardening)

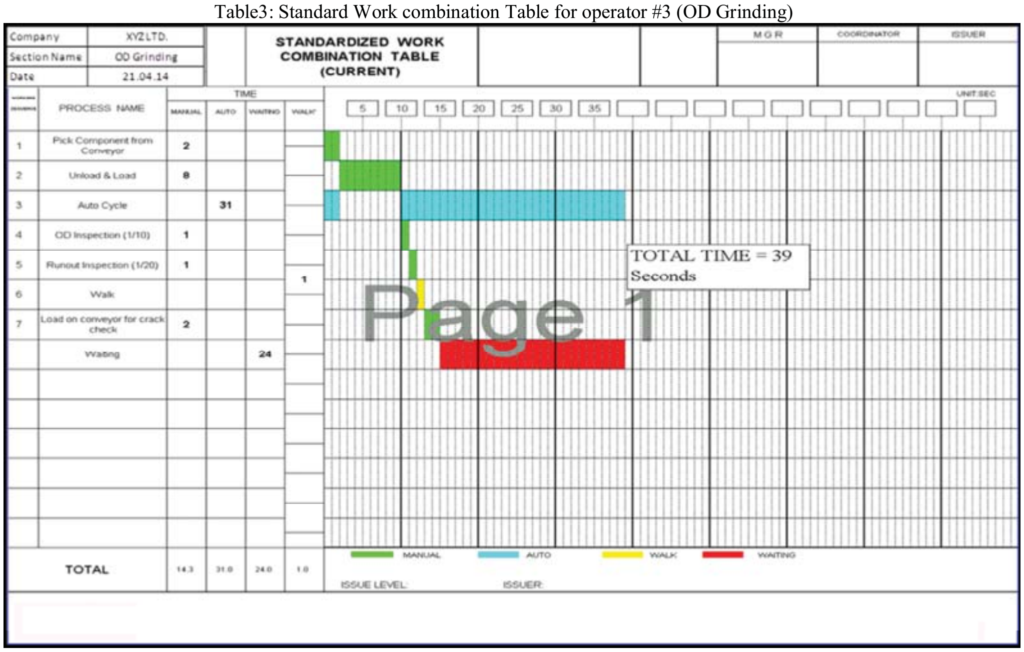


Company	XYZ LTD.
Section Name	Induction Hardening
Date	21.04.14

STANDARDIZED WORK COMBINATION TABLE (CURRENT)

	PROCESS NAME	TIME: MANUAL	AUTO	WAITING	WALK
1	Pick Component from washing	1			
2	Marking	5			
3	Load on machine	3			
4	Waiting			14	
5	Unload from machine & place on the maganatest coil	4			
6	Spline Check	5			
7	Tripod Check	2			
8	Place component on conveyor for next operation	2			
9	Auto Cycle		36		
TOTAL		21.0		14.0	0.0

Table3: Standard Work combination Table for operator #3 (OD Grinding)

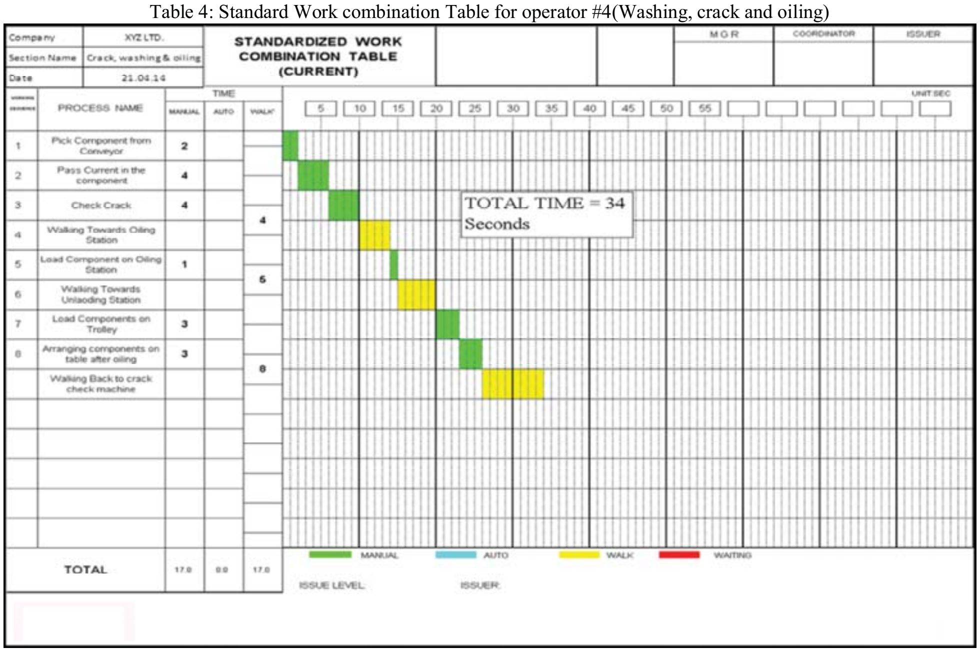


Company	XYZ LTD.
Section Name	OD Grinding
Date	21.04.14

STANDARDIZED WORK COMBINATION TABLE (CURRENT)

	PROCESS NAME	TIME: MANUAL	AUTO	WAITING	WALK
1	Pick Component from Conveyor	2			
2	Unload & Load	8			
3	Auto Cycle		31		
4	OD Inspection (1/10)	1			
5	Runout Inspection (1/20)	1			1
6	Walk				
7	Load on conveyor for crack check	2			
	Waiting			24	
TOTAL		14.3	31.0	24.0	1.0

Table 4: Standard Work combination Table for operator #4(Washing, crack and oiling)



c) Analysis of data and decision making

Once the data has been collected it is analyzed for decision making for loading pattern and making uniform loading of operators, ideal requirement of operator for doing the same job(staffing calculation), present deployment of manpower against the same. The table is the result of data collected by SWCTs prepared by doing time study in the cell. This is mean value of time taken five times for the repeated activities. The table below shows that operator no1 has manual time for which he is actual working is 12 seconds while walking time is 6 seconds for next 10 seconds he is waiting for completion of machine cycle hence he is working only for 12 seconds as value addition to work contents. For next 10 seconds it may be necessary to move for operating the next machine as he is operating two machines simultaneously (grooving and rolling as shown in the cell layout). This operator is loaded for 18 seconds and he remains idle for ten second. For this time this operator can be utilized for doing another activity.

Table 5: Total time distribution for all the four operators

Operator	Manual time	Walking time	Waiting time	Actual cycle time	Target cycle time	Unassigned time
Rolling & Grooving	12	6	10	28	39.98	11.98
Induction hardening	22	0	14	36	39.98	3.98
OD Grinding	14	1	24	39	39.98	0.98
Crack, wash & oiling	17	17	0	34	39.98	5.98
Total	65	24	48	137	39.98	22.98

Actual work content for operator no1 it is 28 seconds as compare with the target cycle time of 40 seconds, this also shows that his work content are already short by 12 seconds. This time can also be utilized for doing another job in addition of waiting time of ten seconds. After analysis it was concluded that operator no.1 can be assigned another job of 22 seconds and in present condition he is under-loaded as per pull system.

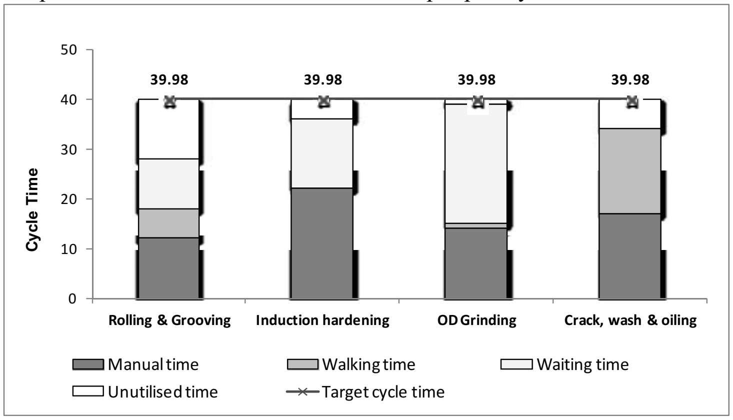


Figure 4: Current state of Line balancing based on Standard Work Combination Table

Summary Report:

Takt Time:	= 45 Seconds
Target Cycle Time:	= 39.98 Seconds
Customer Requirement	=1720 parts
Total Work Unit Manual Time:	=64 Seconds
Total Work Unit Walk Time:	=24 Seconds
Total Work Unit Wait Time:	=48 Seconds
Target work unit staffing:	=2.80
Longest Operator Actual Cycle Time:	=39 Seconds
Longest Operator Actual Cycle Time Vs Target Cycle Time	= 39 Vs 39.98

Calculation of operator required.

No. of operators required

$$= \frac{\text{Total Manual Time} + \text{Total Walk Time}}{\text{Target Cycle Time}}$$

$$= \frac{(12+22+14+17) + (6+1+17)*2}{39.98}$$

= 2.80 Operators at one time

(Note: Considering that walk time will double as the m/c's are far apart.)

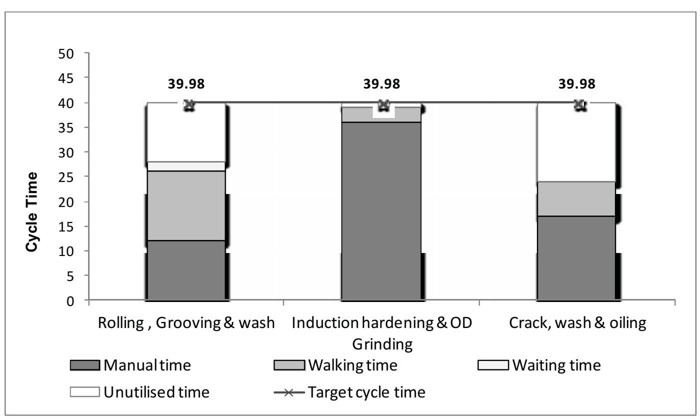


Figure5: Line balancing after implementation of Standard work

d) *Implementation of actions decided,*

i. Operator activities redefined: Operator activities were redefined to achieve uniform loading in the cell. Number of operators was reduced from four to three by providing equal load to each operator. Operator running induction hardening machine was deployed to run outer diameter grinding machine to reduce waiting time.
ii. Training / motivation to operators for synchronized work: Operators were trained to work in a team as per changing requirement of standardized work environment. Proper incentive scheme was also introduced for the operators working at two stations simultaneously.
iii. Batch production switched into single piece flow: A trolley containing 250 nos. of components was used to carry parts in work in progress area resulting in time lost in loading/unloading the trolley along with space occupation in the cell. It was eliminated by providing conveyors in the cell hence resulted in replacing batch production in single piece flow in the line. After that only two trolleys were under use one at the Material-IN and second at Material-Out point.
iv. Reduction of changeover time: To improve flexibility in manufacturing system changeover time was reduced at one of the machine (grooving). In the case example different holding fixtures were required for different models, which was time consuming no value added activity. Fixture was modified such that one common fixture was able to hold all the models hence reduction of changeover time from 30 minutes per changeover to only 10 minutes.

e) Monitoring and comparison of the results

After implementation of Standard work as Lean Manufacturing enabler it was observed that the gain is reduction in manpower from four to three resulting in increase in productivity by 24.8% i.e. from 21.2 parts per man per hour to 28.2 parts per man per hour. Trolleys system was changed to conveyor in the cell for material handling resulting in reduction in WIP from 500 nos. of part at a time to 130 parts at any time. Reduction in change-over time by introduction of new design of fixture by 66.68% i.e. from 30 minutes to 10 minutes per change- over was observed.

V CONCLUSION

The real life case has been studied to examine the implication of Lean manufacturing in operational performance of manufacturing processes. Major contributor in Lean Manufacturing implementation studied was Standard work as enabler of Lean Manufacturing. It is observed that implementation of Standard work has resulted in improvement of labor productivity, reduction in WIP inventory and improved flexibility by reducing changeover time. This improvement have financial impact as saving of one operator per shift will improve labor cost per part manufacturing and hence direct impact on financial results. Concurrently employee's involvement in operational results improvement will positively impact morale of employees. This kind of examples have positive impact on organisational Performance of the Indian industries and benefits gained with implementation of Standard work will also have excellent impact Lean manufacturing drive in Indian industry. Indian industry should focus on Lean Manufacturing implementation to improve productivity, quality, cost competitiveness, reduce inventory, improve flexibility and get better financial results to stay competitive in global market.

REFERENCES

[1] Ahuja I.P.S and Khamba J.S., (2008),"An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance", International Journal of Quality & Reliability Management, Vol. 25 Issue: 2 pp. 147 – 172

[2] Ahuja I.P.S and Khamba J.S., (2008),"Assessment of contributions of successful TPM initiatives towards competitive manufacturing", Journal of Quality in Maintenance Engineering, Vol. 14 Issue: 4 pp. 356 – 374.

[3] Amasaka K. (2002) ''New JIT: A new management technology principle at Toyota", International Journal of Production Economics 80 135–144.

[4] Anand G. and Kodali R, (2009),"Selection of lean manufacturing systems using the analytic network process - a case study", Journal of Manufacturing Technology Management, Vol. 20 Issue: 2 pp. 258 – 289

[5] Anand G. and Kodali R., (2008),"Selection of lean manufacturing systems using the PROMETHEE", Journal of Modeling in Management, Vol. 3 Issue: 1 pp. 40 – 70

[6] Antony J., Desai DA., (2009),"Assessing the status of six sigma implementation in the Indian industry: Results from an exploratory empirical study", Management Research News, Vol. 32 Issue: 5 pp. 413 – 423.

[7] Belokar R.M., Kumar V, Kharb S.S.2012, "An Application of Value Stream Mapping In Automotive Industry: A Case Study," International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-1, Issue-2, July 2012.

[8] Chan FTS, (2001)," Effect of Kanban size on Just-in-time manufacturing system". Journal of materials processing technology 116, 146-160.

[9] Chen Z-X and Tan K. H., (2011),"The perceived impact of JIT implementation on operations performance: Evidence from Chinese firms", Journal of Advances in Management Research, Vol. 8 Issue: 2 pp. 213 – 235.

[10] Chowdary B.V, George D., (2011),"Improvement of manufacturing operations at a pharmaceutical company: A lean manufacturing approach", Journal of Manufacturing Technology Management, Vol. 23 Issue: 1 pp. 56 – 75.
[11] Deif A., 2012," Assessing Lean Systems Using Variability Mapping," Available online at www.sciencedirect.com,SciVerse Science Direct Procedia CIRP 3 (2012) 2 – 7.
[12] Dombrowskia U., Mielkea T., Engel C., 2012," Knowledge Management in Lean Production Systems," Available online at www.sciencedirect.com,SciVerse Science Direct Procedia CIRP 3 (2012) 436 – 441.
[13] Ferdousi F. and Ahmed A., (2009) "An Investigation of Manufacturing Performance Improvement through Lean Production: A Study on Bangladeshi Garment Firms", International Journal of Business and Management volume l4, No 9 pp 106-116.
[14] Haan, J. D and Yamamoto M,(1999),"Zero inventory management: facts or fiction? Lessons from Japan", International Journal of Production Economics 59, (1999) 65Ð75.
[15] Joseph C. Chen1, Ronald A. Cox, 2012, "Value Stream Management for Lean Office—A Case Study", American Journal of Industrial and Business Management, 2012, vol. 2, 17-29
[16] Joshi R.P. , Naik G.R., 2012, Process Improvement by using Value Stream Mapping:- A Case Study in Small Scale Industry," International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 5, July – 2012, ISSN: 2278-0181.
[17] Kengar V.S., Kadam S.J, Pandit S.V., Ingale MV, 2013, "Manufacturing System Performance Improvement by Value Stream Mapping a Literature Review" International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 2, Issue 9, September 2013, ISSN: 2319-8753.
[18] Kumar Rakesh and Kumar Vikas, 2012," Lean Manufacturing System: An Overview," Proceedings of the National Conference on Trends and Advances in Mechanical Engineering, YMCA University of Science & Technology, Faridabad, Haryana, Oct 19-20, 2012
[19] Kumar S., Singh B, Qadri Md. Asim, Kumar Y.V. Satya and Haleem Abid, 2013" A framework for comparative evaluation of lean performance of firms using fuzzy TOPSIS", Int. J. Productivity and Quality Management, Vol. 11, No. 4, 2013.
[20] Kumar V. (2010), "JIT Based Quality Management: Concepts and Implications in Indian Context", International Journal of Engineering Science and Technology Vol.2 (1), pp 40-50.
[21] Liker, J.K. and Wu, Y.C., (2000), "Japanese automakers, US suppliers and supply-chain superiority", Sloan Management Review 42, pp 81-93
[22] Mishra O.P., Kumar V. Garg D., (2013)," JIT supply chain: An investigation through general system theory" Management Scienec Letters Volume 3 Issue 3 pp. 743-752, 2013.
[23] Mohanty R. P., Yadav O. P. and Jain R.,(2006), "Implementation of Lean Manufacturing Principles in Auto Industry", Vilakshan, XIMB Journal of Management pp1-32.
[24] Narain R, Yadav R.C., Antony J, (2004),"Productivity gains from flexible manufacturing: Experiences from India", International Journal of Productivity and Performance Management, Vol. 53 Issue: 2 pp. 109 – 128
[25] Nordin N, Deros B Md. and Wahab D.A. ,(2010) "A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry", International Journal of Innovation, Management and Technology, Vol. 1, No. 4, October 2010 ISSN: 2010-0248 Pp 374-380.
[26] Nordin N. and Baba Md. Deros, Dzuraidah Abdul Wahab,2011" Lean Manufacturing Implementation in Malaysian Automotive Industry: An Exploratory Study, OPERATIONS AND SUPPLY CHAIN MANAGEMENT Vol. 4, No. 1, January 2011, pp. 21-30 ISSN 1979-3561|EISSN 1979-387.
[27] Oehmen, Josef, (Ed.).2012.The Guide to Lean Enablers for Managing Engineering Programs, Version1.0.Cambridge, MA: Joint MIT-PMI-INCOSE Community of Practice on Lean in Program Management. URI: http://hdl.handle.net/1721.1/70495.
[28] Pepper M.P.J., Spedding T.A., (2010),"The evolution of lean Six Sigma", International Journal of Quality & Reliability Management, Vol. 27 Iss: 2 pp. 138 – 155.
[29] Rahman S., Laosirihongthong T, Sohal A.S. , (2010),"Impact of lean strategy on operational performance: a study of Thai manufacturing companies", Journal of Manufacturing Technology Management, Vol. 21 Issue: 7 pp. 839 – 852.
[30] Saraswat P., Sain M.K., Kumar D., "A Review on Waste Reduction through Value Stream Mapping Analysis", International Journal of Research (IJR) Vol-1, Issue-6, July 2014 ISSN 2348-6848.
[31] Shah R. and Ward P.T., (2003), "Lean manufacturing: context, practice bundles, and performance, Journal of Operations Management 21, pp. 129–149.
[32] Shah R. and Ward P.T., (2007)," Defining and developing measures of lean production", Journal of Operations Management 25 (2007) pp 785–805.
[33] Silva S.K.P.N., 2012,"Applicability of Value Stream Mapping (VALUE STREAM MAPPING) in the Apparel industry in Sri Lanka", International Journal of Lean Thinking Volume 3, Issue 1 (June 2012), pp 36-41.
[34] Singh B, Garg S.K., Sharma S.K., (2009),"Lean can be a survival strategy during recessionary times", International Journal of Productivity and Performance Management, Vol. 58 Issue: 8 pp. 803 – 808
[35] Singh B, Garg S.K., Sharma S.K., (2010a) "Lean implementation and its benefits to production industry", International Journal of Lean Six Sigma Vol. 1 No. 2, pp. 157-168
[36] Singh B, Garg S.K., Sharma S.K.,, (2010b)," Development of index for measuring leanness: study of an Indian auto component industry", Measuring Business Excellence, vol. 14 no. 2, pp. 46-53, Emerald Group Publishing Limited, ISSN 1368-3047
[37] Singh B, Garg S.K., Sharma S.K., (2010c) "Value stream mapping: literature review and implications for Indian industry", International Journal of Advance Manufacturing Technology DOI 10.1007/s00170-010-2860-7 Published online on 10th August 2010.
[38] Singh T. and Dubey R., (2013) "Soft TQM practices in Indian cement industry –an empirical study", Int. J. Productivity and Quality Management, Vol. 11, No. 1, 2013,pp.1-2.
[39] Taj S. and Morosan C., (2011),"The impact of lean operations on the Chinese manufacturing performance", Journal of Manufacturing Technology Management, Vol. 22 Issue: 2 pp. 223 – 240
[40] Upadhye N and Deshmukh S. G.,(2010), "Suresh Garg, Lean manufacturing system for medium size manufacturing enterprises: an Indian case", International Journal of Management Science and Engineering Management, 5(5): 362-375,
[41] Vikas K., Garg D and Mehta N.P. ,(2004) , "JIT practices: in Indian context", Journal of scientific and Industrial research, Vol. 63 pp 655-662.
[42] Womack, J.P., Jones, D.T. and Roos, D. (1990) The Machine that Changed the World, Harper Perennial, New York
[43] Wong Yu C.* and Wong K.Y, Ali A.,(2009), "A Study on Lean Manufacturing Implementation in the Malaysian Electrical and Electronics Industry", European Journal of Scientific Research ISSN 1450-216X Vol.38 No.4, pp 521-535
[44] Wong Yu C.* and Wong K.Y.,(2011a) "Approaches and practices of lean manufacturing: The case of electrical and electronics companies",

African Journal of Business Management Vol.5 (6), pp. 2164-2174,
[45] Wong Yu C.* and Wong K.Y.,(2011b)," A Lean Manufacturing Framework for the Malaysian Electrical and Electronics Industry",3rd International Conference on Information and Financial Engineering.
[46] Garg D, Deshmukh S G & Kaul O N," Attribute for JIT purchasing and supplier evaluation: A survey", Productivity, 38 (1996) p 322-326.