

# Applications of Lean Six Sigma Methodologies for Improvement in Industrial Safety

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## Abstract

This Paper is about integration of Six Sigma and Lean Methodologies for reduction in number of accidents in a Manufacturing Industry. The problem identified is ignorance about safety protocols among workers. To achieve low accident, rate the central methodology implemented is DMAIC (Define, Measure, Analyze and Control). Various statistical and quality tools such as SIPOC, Cause and Effect Analysis, FMEA, Root Cause Analysis, 5-S Audit, 5-Why Analysis, etc are used within the five stages of DMAIC. To conclude, Results after Improvement Phase and projected recommendations to the factory are presented.

**Keywords: Derivation for Sigma Formula, DMAIC, Lean, Manufacturing Industry, Safety, Six Sigma**

## I. INTRODUCTION

The integration of lean and six sigma principals for industrial safety ensures a result oriented, project focused approach to quality, productivity and profitability which results in cost savings and profit growth. Lean includes methodologies to eliminate wastage from any manufacturing process while considering waste generation due to unevenness and overburden.[1] Six Sigma includes methodologies to eliminate defects form any manufacturing process. These methodologies are used with a goal to reduce the number of accidents occurring in a Casting Industry. Safety Management is an organizational function which ensures that all safety risks have been identified, assessed and satisfactorily mitigated.

The objectives for the research are:

- 1) To reduce the number of accidents occurring inside the industry.
- 2) To identify hazards and risk controls while maintaining assurance that these risk controls are effective.
- 3) To improve a workers efficiency of working and ensuring his safety in the industry premises.
- 4) To avoid Industrial Production shut down and avoid financial loss
- 5) Encourage use of Standard Safety Equipments and safety procedures in the industry.
- 6) Show step by step method for sigma value calculations, with formula and its derivation.

## II. DEFINE PHASE

This is a Problem Identification Phase in which we carry out detection of safety related problems of the Industry. Problems were detected by observing the functional process going inside the industry and with the help of communicating with labors and personnel managers working inside the industrial premises. We used five tools in this phase SIPOC, SMART, PDCA, SWOT analysis and Cause and Effect analysis.

### A. SWOT Analysis:

(Strengths, Weakness, Opportunities and Threats.) It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective.

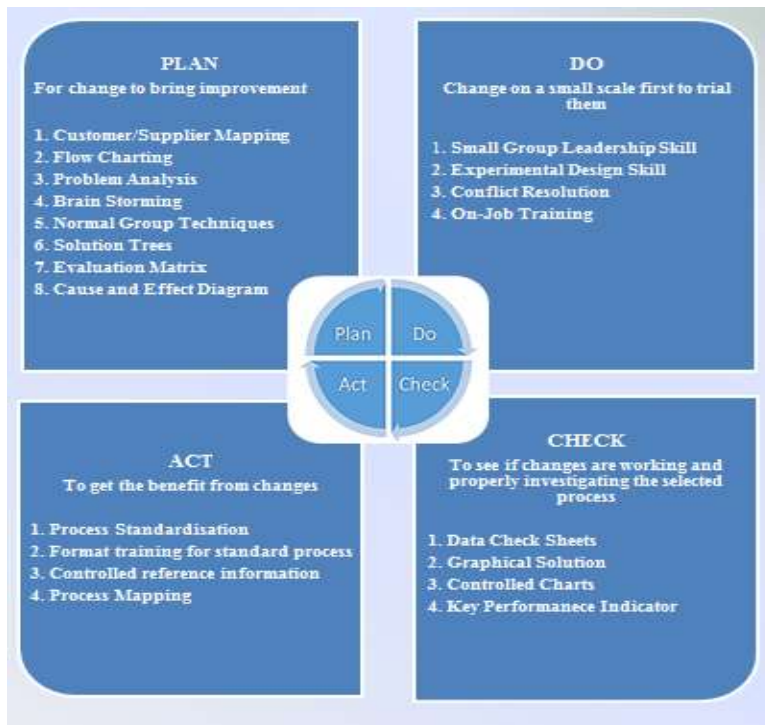


Fig. 1: Pdca Chart: This Chart Helps Us to Plan Define Check and Act According To The Problems We Have Got

Table- 1  
SWOT Analysis

	<i>Helpful to Achieving Goal</i>	<i>Harmful to Achieving Goal</i>
<i>Internal</i>	<p><i>Strengths</i></p> <ul style="list-style-type: none"> <li>Skilled Labor</li> <li>Efficient Management</li> <li>Effective Plant Layout</li> <li>Large Workspace</li> </ul>	<p><i>Weaknesses</i></p> <ul style="list-style-type: none"> <li>Contract Labors</li> <li>Improper Safety Protocols</li> <li>Non-efficient Maintenance</li> <li>Furnace area safety undermined</li> </ul>
<i>External</i>	<p><i>Opportunities</i></p> <ul style="list-style-type: none"> <li>Market Connectivity</li> <li>Good Transport Facilities</li> <li>Low Cost Labor</li> <li>Raw Material Availability</li> </ul>	<p><i>Threats</i></p> <ul style="list-style-type: none"> <li>Workers ignore safety procedures</li> <li>Molten Metal Handling Hazard</li> <li>No Nearby Hospitals</li> </ul>

**B. SIPOC Chart:**

Here in this chart we take into account the Supplier, Input, Process, Output and Consumer

Table- 2

SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
FIELD ENGINEERS	PROJECT	WORK IS ASSIGNED	SAFE BEHAVIOUR	WORKER
AUTOMOTIVE DEPARTMENT	VEHICLES	VEHICLES TOOLS AND MATERIAL IDENTIFIED	ZERO INJURY	WORKER
SAFETY DEPARTMENT	SAFETY RULES	CONSTRUCT WORK	IMPROVEMENT IN WORKER'S EFFICIENCY	WORKER
PRODUCT ENGINEER	MATERIAL	COMPLETE HAZARD ASSESSMENT	SAFE WORK PROCEDURE	WORKER

**C. Cause and Effect Analysis:**

Cause and effect analysis technique is used to identify all the causes and optimize the potential ones. The effect being occurrence of an accident, various causes were identified by classifying them into different sections. Multiple causes are listed here in a figure below which contribute to the occurrence of an accident in the industry.

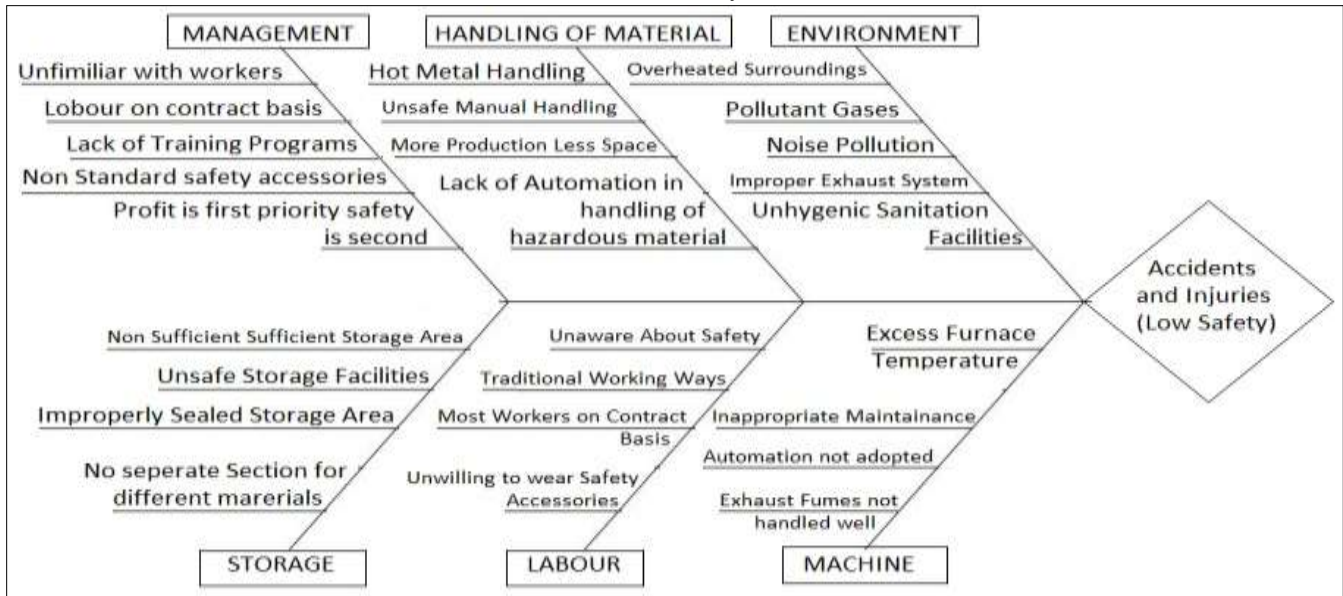


Fig. 2: Fishbone Diagram for Cause and Effect Analysis

**III. MEASURE PHASE**

This phase involves numerical studies and analysis of data obtained during the DEFINE phase with the focus on measurement system validation and gathering root causes. Here we have also done a 5-S Audit to note down the possible causes and sectors among which improvement is necessary.

**A. A.5-S Audit:**

A 5-S(Sort, Straighten , Shine, Standardize, Sustain.) + Safety sheet is shown here. It requires to mark yes or no in the sheet and then to calculate section score. The total score is then divided by six to obtain audit score. This score on a 0 to 6 scale shows which section of the plants requires most attention and which can be taken care of later.

A 5S Audit sheet for Furnace Section is shown here. [3]

Similar Audits were conducted for all six sections of the plant. Their Audit score is given below:

- 1) Furnace Section : 2.0
- 2) Casting Section : 2.0
- 3) Inventory Section : 2.17
- 4) Machining Section : 2.34

Production – Safety and 5S Audit (Before)			
Plant /Dept./Cell - Machining Section	Audit Date - 25/10/2015		
Auditor – PRG			
Total Score 14/6 = 2.34	[Total score calculation : Total section score, then divide by 6 (1=yes/0=No)]		
<b>SAFETY</b> Keep clutter out of the area	Score	0 1 0 1 0	Is the entire emergency exit clearly visible, not blocked and illuminated? Are all extinguisher and emergency equipment visible, mounted, and accessible with inspection up to date? Are all employees wearing proper PPE (Shoes, Glasses, Ear plugs), if welding additional gears. Are floors free from oil, water, cords that may cause a fail. Are electrical panels accessible and proper procedures posted?
	Score	0 1 0 1	Are only commonly used (>1 week) parts tools and fixtures located in the area. Is inventory( VVIP and finished goods) properly identified and stored in the designed area Are SQD IP cell board poster signs and notices current and up to date with proper revision control documentation? Are work instruction and print organized accessible current and no hand written notes for the work to be done Are storage cabinets eliminated from form the area?

<p><b>STRAIGHTEN</b> A place for everything and everything in its place</p>	Score	1	Are position of main corridors, are clearly marked
		1	Are all material drop zones clearly marked in the green and are clear
		0	Are tool board organized labeled with no tools inside 'A' frame board and there no missing tools
		0	Are all drawing , information sheets, and shelves organized and clearly labeled
		0	All gauge, tools fixture and information board stored at the labeled
<p><b>SHINE</b> Clean and check to reveal problem and improve the environment</p>	Score	1	Are walls, floor and columns bright and clean( fresh paint)
		0	Are the light bulbs reflectors, top of machine, cabinet, material pins and fixtures clean and free to debris and dust
		1	Are the light bulbs in the operating conditions (Not burn out)
		1	Are work surfaces and equipment clean
		1	Are the information boards and visual controls clean and readable?
<p><b>SUSTAIN</b> Make the 5-S system part of everyday life</p>	Score	0	Are 5S audit done on time by the supervisor
		1	Are abnormal conditions visually and easily identifiable
		0	Are 5S improvements being incorporated regularly using counter measures sheet?
		0	Is 5S audit score above 6.0 for the area?
		0	Has progress been made on the action plan since last review.

Fig. 3: Safety and 5S Audit for Machining Section

Since Audit score of Furnace section is lowest, safety regulations in Furnace Section are first priority. The order of audit score gives us the sections in the plant which requires attention in a set preference.

**IV. ANALYZE PHASE**

The basic step followed under this phase is defining performance objectives, identifying various sources of errors and establishing process capability. We are using different statistical tools to analyze the cause of accidents that have been identified in previous phases. The tools used in this section are 5 Why Analysis, Root Cause Analysis and FMEA.

**A. 5-Why + Safety Analysis [3]:**

<b>ROOT CAUSE ANALYSIS – 5 WHY</b>				
<i>No Gas Mask in Furnace Area.</i>				
<i>Originator's Name : Ashutosh Kumar Singh</i>		<i>Date : 25 OCT 2015</i>		
<b>Problem Description:</b>				
<i>During melting iron in furnace, large amount of smoke is generated which are harmful for human. Workers working in furnace section are not using gas mask which is not good for workers.</i>				
<b>5 Why's – "Why Made"</b>				
<b>Why #1- Worker</b>				
	<i>Why #2 – Worker are not use gas masks.</i>			
	<i>Why #3 – While working in furnace sections.</i>			
	<i>Why #4 – Furnace sections.</i>			
	<i>Why #5 – Unaware about problems.</i>			
<b>5 Why's – "Why Missed" (If Applicable)</b>				
<b>Why #1 – Worker</b>				
	<i>Why #2 – Use mask during in furnace sections.</i>			
	<i>Why #3 – While working in furnace sections.</i>			
	<i>Why #4 – Furnace section</i>			
	<i>Why #5 – For avoiding harm by industrial gases and smokes.</i>			
<b>Corrective Actions</b>		<b>Who</b>	<b>When</b>	<b>Status</b>
<i>Wear gas masks</i>		<i>Worker</i>	<i>In furnace section</i>	<i>Implemented</i>
<i>Don't allow workers in furnace section without safety gears</i>		<i>Supervisor</i>	<i>Furnace Section</i>	<i>Under consideration</i>

Fig. 5: 5-Why Analysis Sheet, Gas shield for workers in furnace department

**B. Failure Mode Effect Analysis (FMEA) [4]:**

Function process	Failure type	Severity	Occurrences	Detection	Risk priority no.
Handling of molten metal	It can be get slip off from the hands of labour and he may get injured	5	8	6	240
Pouring of molten metal in the moulds	They have not proper safety equipment's with them	7	6	5	210
Transferring of raw material	Congested areas for working and machining and improper path	8	6	4	192

Direct contact with molten metal	Without any fire resisting equipment	4	5	3	60
Inventory or storage of material	Improper storage of material	6	6	4	144
Slag is cooled by water.	Smoke is generated	3	5	4	60
Worker working in the furnace section and near sand blasting machine	Working near furnace section or machine section, any machining component may strike on worker's head	4	5	5	100

Fig. 4: FMEA Analysis for various problems noted in the industry. The RPN Value indicates which problem is most hazardous for workers concerning their safety.

**C. Root Cause Analysis [5]:**

A Sample RCA report for the Furnace Department of the industry is shown here. As problems are identified and decisions are made we must make the decision on the best method for solving the issue. Similar Reports were made for all the six major problems identified in define phase.

**1) Root Cause (Furnace)**

<div style="display: flex; justify-content: space-between;"> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="background-color: black; width: 15px; height: 15px; margin-bottom: 5px;"></div> Safety             </div> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="background-color: black; width: 15px; height: 15px; margin-bottom: 5px;"></div> Productivity             </div> </div>		Approvals	Managers	Production	Lean	Engineering	Quality	Safety
<div style="display: flex; justify-content: space-between;"> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="background-color: black; width: 15px; height: 15px; margin-bottom: 5px;"></div> Quality             </div> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="background-color: black; width: 15px; height: 15px; margin-bottom: 5px;"></div> Inventory             </div> </div>		Root Cause						
<div style="display: flex; justify-content: space-between;"> <div style="background-color: black; width: 15px; height: 15px; margin-bottom: 5px;"></div> Delivery             </div>		Corrective						

Originator	Report Date	Customer Affected	Department	Root Cause Analysis and corrective actions - "Why Made"?	Why did the Workers in scrap
	25 Oct 15	NIL	Furnace	melting furnace. Do not wear gas mask When? While inserting scraps in furnace. Where? Scrap Melting furnace area. Why? Inadequate supervision and safety training for furnace workers.	Who? What?
Problem Description:				Root Cause Analysis and Corrective Action - "Why Missed"?	
Workers in furnace area do not wear gas mask.				Was this problem not caught by the normal system?	
Problem Solving team members:				Workers in the furnace section use their own scarf to prevent inhaling furnace fumes.	
Ashutosh K Singh, Govind T Gaurikar.					
Containment actions/ Protect the Customer?		Date Completed.			
Gas Mask has been provided for the workers working near the furnace area.		30 Oct 15			
Detailed description of the problem. (includes details, photos and sketches).				Corrective Actions	Completion Date
Workers in furnace section do not wear gas mask and prefer their own scarf over their face. Unawareness of hazards or inhaling furnace fumes is redundant.				Gas Mask allotted to furnace section in every furnace	30 Oct 15
Evaluate Corrective Action				Person Responsible	Due Date
Gas mask has been allotted to every worker in furnace and training has been given to every worker in the furnace area.					30 Oct 15
Standardize					
Point of the cause. where/how did the problem occur?				Have we been trained to the standard?	Is the standard adequate?
Workers start wearing scarf instead of gas mask to protect them from gas mask. Gas mask was soon discontinued by the workers and supervisors and management avoided buying new gas mask since the workers do not use them.				Did we follow the standard?	Yes Yes No
Knowledge Sharing - Plan to share knowledge to other cell. sites.					
Reports send to the management, Safety and all Supervisors.					

Fig. 6: Root Cause (Furnace)

**V. MPROVE PHASE**

We note down the improvements done and to see if each department shows effects of improvement we do a 5-S Audit again and see if the audit score for each department increases or not. The tools used in this phase are 5-S Audit, Safety Control Sheet, Safety Improvement Plan and Post Kaizen EHS Checklist.

Also the improved sigma level of the plant is calculated based on the information obtained by questionnaires and frequent site visits.

**A. 5-S Audit System [7]:**

The scores are subjectively rated from 0 to 5 as whole numbers with the following criteria as a guide:

- 1) zero effort, no evidence, not started

- 2) activity started with minimal effort but not sustainable
- 3) widespread activity with more opportunity for improvement
- 4) minimum acceptable level sustained for a month
- 5) all encompassing activity and sustained for over a month
- 6) best in class and sustained for at least six months

A sample 5-S Audit done after improvement phase for the Furnace Section of the factory is shown here. [3]

Similar audits were done for all the six sections of the industry.

Their Audit score is given below:

- 1) Furnace Section : 3.17
- 2) Inventory Section : 3..83
- 3) Casting Section : 4.0
- 4) Machining Section : 4.34

Plant /Dept./Cell - Machining Section		Production – Safety and 5S Audit (Afier)		Auditor – PRG
Total Score 26/6 = 4.34		Audit Date – 18/03/201		
[Total score calculation : Total section score, then divide by 6 (1=yes/0=No)]				
<b>SAFETY</b>  Keep clutter out of the area	Score	1	Is the entire emergency exit clearly visible, not blocked and illuminated?	
		1	Are all extinguisher and emergency equipment visible, mounted, and accessible with inspection up to date?	
		0	Are all employees wearing proper PPE (Shoes, Glasses, Ear plugs), if welding additional gears.	
		1	Are floors free from oil, water, cords that may cause a fail.	
		1	Are electrical panels accessible and proper procedures posted?	
<b>SORT</b>  Keep what is needed throw out the rest	Score	0	Are only commonly used (>1 week) parts tools and fixtures located in the area.	
		1	Is inventory( VVIP and finished goods) properly identified and stored in the designed area	
		0	Are SQD IP cell board poster signs and notices current and up to date with proper revision control documentation?	
		1	Are work instruction and print organized accessible current contained and no hand written notes for the work to be done	
		1	Are storage cabinets eliminated from form the area?	
<b>STRAIGHTEN</b>  A place for everything and everything in its place	Score	1	Are position of main corridors, are clearly marked	
		1	Are all material drop zones clearly marked in the green and are clear	
		1	Are tool board organized labeled with no tools inside 'A' frame board and there no missing tools	
		1	Are all drawing , information sheets, and shelves organized and clearly labeled	
		1	All gauge, tools fixture and information board stored at the labeled	
<b>SHINE</b>  Clean and check to reveal problem and improve the environment	Score	1	Are walls, floor and columns bright and clean( fresh paint)	
		1	Are the light bulbs reflectors, top of machine, cabinet, material pins and fixtures clean and free to debris and dust	
		1	Are the light bulbs in the operating conditions (Not burn out)	
		1	Are work surfaces and equipment clean	
		1	Are the information boards and visual controls clean and readable?	
<b>STRANDARDIZE</b>  Apply common standards and visual management to the area	Score	1	Are 5S responsibilities identified and all employees trained	
		1	Are all storage/ equipment area marked and labeled consistent understandably	
		0	Is zone champion leadership standardized work defined by cell and completed on time. Is visual management standardized	
		1	Does supervisor LSW audit the success of 5S and the zone champion LSW?	
<b>SUSTAIN</b>  Make the 5-S system part of everyday life	Score	1	Are 5S audit done on time by the supervisor	
		1	Are abnormal conditions visually and easily identifiable	
		1	Are 5S improvements being incorporated regularly using counter measures sheet?	
		1	Is 5S audit score above 6.0 for the area?	
		1	Has progress been made on the action plan since last review.	

Fig. 7: Safety and 5S Audit for Machining Section

## VI. CONTROL PHASE

Control Phase is the last phase of DMAIC Methodology implemented in our project. Here we try to sustain the developments made in improve phase and aim towards continuous improvement. It is made sure that the sigma value never degrades in the factory. The tools used here to ensure continuous improvement are Safety Improvement Plan and Post Kaizen EHS Checklist.

**A. Safety Improvement Plan:**

<i>Safety Improvement Plan Agreement Non-Supervisor Program</i>			
<i>I, Devidas Dhote understand that I have been identified as an “at risk” employee under Safety Improvement Plan. Under the SIP Program, Section 3.2 “Any employee who has a rate of two or more accidents or incidents within six months or recordable incidents within twelve months will be identified as needing to be involved in SIP”.</i>			
<i>I understand that I have incurred the following incidents that have identified me as an “at risk” employee.</i>			
#	Date	Injury Type	Description of Injury
1	14 Sept 14	<input type="checkbox"/> First Aid <input checked="" type="checkbox"/> Recordable <input type="checkbox"/> Lost Time <input type="checkbox"/> Property Damage	Broke wrist during moving iron bar
2	23 Nov 14	<input checked="" type="checkbox"/> First Aid <input type="checkbox"/> Recordable <input type="checkbox"/> Lost Time <input type="checkbox"/> Property Damage	Sprained Shoulder while lifting iron bar
3	7 Jan 15	<input type="checkbox"/> First Aid <input type="checkbox"/> Recordable <input checked="" type="checkbox"/> Lost Time <input type="checkbox"/> Property Damage	Obstructed crane while carrying iron bars
4	13 Mar 15	<input checked="" type="checkbox"/> First Aid <input type="checkbox"/> Recordable <input type="checkbox"/> Lost Time <input type="checkbox"/> Property Damage	Burnt hand by touching hot iron case
<i>I, Devidas Dhote have chosen to complete the following actions to fulfill my obligation to the SIP Program.</i>			
<ul style="list-style-type: none"> <li>– Conduct 4 department safety inspections.</li> <li>– Participate in department safety training.</li> <li>– Implement 2 or more safety improvements for their department.</li> <li>– Give a safety talk to your department.</li> <li>– Complete a work site analysis for specific work area.</li> <li>– Complete a job safety analysis for a specific hazardous job.</li> <li>– Identify four unsafe conditions or acts happening in your area, and determine ways to prevent them.</li> <li>– Attend a safety committee meeting.</li> <li>– Assist in hazard assessment.</li> </ul>			
<i>I, Devidas Dhote understand that if at any time I choose to stop participation in, or activity related to this SIP I will be subject to additional action to include disciplinary action as deemed by Human Resources.</i>			
<i>SIP Participant: Devidas Dhote</i>		<i>EHS Representative: PRG</i>	
<i>Supervisor: Sudhir Rajat</i>		<i>HR Representative: Naresh Shiple</i>	

Fig. 8: Sip Agreement for Workers

**B. Post Kaizen EHS Checklist[3]:**

Table – 4  
Post Kaizen EHS Checklist (To ensure that no safety or environmental issues were created during the event)

Area	#	Question	Yes	No	N/A	Notes/Issues
<i>Ergonomics</i>	1	<i>Reduce the amount of lifting required for job?</i>			<input checked="" type="checkbox"/>	<i>Introduction of scraps into furnace 1 for melting requires manually pushing the scrap into the furnace.</i>
	2	<i>Create a Push/Pull/Carry task for the process?</i>			<input checked="" type="checkbox"/>	
	3	<i>Eliminated one-hand lifts or team lift process?</i>		<input checked="" type="checkbox"/>		
	4	<i>Created a one-hand lift or team lift process?</i>	<input checked="" type="checkbox"/>			
	5	<i>Reduced vibration contact with power hand tools?</i>			<input checked="" type="checkbox"/>	
	6	<i>Increase lowering task instead of creating lifting task?</i>	<input checked="" type="checkbox"/>			
	7	<i>Is ergonomic matting in place for static workstations?</i>	<input checked="" type="checkbox"/>			
	8	<i>Has lifting been changed and/or is sufficient for job task?</i>	<input checked="" type="checkbox"/>			
<i>Safety</i>	1	<i>Moved any fire protection equipment?</i>	<input checked="" type="checkbox"/>			<i>It is ensured that a worker shovels only a fixed quantity into the furnace to avoid spraining their shoulders.</i>
	2	<i>Requires the use of powered industrial vehicle, PIT?</i>		<input checked="" type="checkbox"/>		
	3	<i>Changed egress or exit routes?</i>	<input checked="" type="checkbox"/>			
	4	<i>Eliminated extension cords or power tools?</i>			<input checked="" type="checkbox"/>	
	5	<i>Created any job safety analysis, JSA documents</i>	<input checked="" type="checkbox"/>			
	6	<i>Changed a Lockout/Tag out procedure?</i>		<input checked="" type="checkbox"/>		
	7	<i>Has piping been properly labeled with contents and flow?</i>			<input checked="" type="checkbox"/>	
	8	<i>Have any chemicals been eliminated or added?</i>			<input checked="" type="checkbox"/>	
<i>Environmental</i>	1	<i>Eliminate any type of energy use? Machines/Lights left on?</i>	<input checked="" type="checkbox"/>			<i>The furnace fumes generated in the process cannot be prevented and the management currently is not ready to focus on environment problems.</i>
	2	<i>Eliminate any water waste in the process? Process cleanup wastewater, etc.?</i>		<input checked="" type="checkbox"/>		
	3	<i>Eliminate any type of air waste? Sanding dust, chemicals evaporation.</i>		<input checked="" type="checkbox"/>		
	4	<i>Eliminate any type of solid waste? Universal trash, scrap, etc.?</i>		<input checked="" type="checkbox"/>		
	5	<i>Eliminate or minimize the disposal hazardous waste? Solvent, Paint, Degreasers, etc.</i>		<input checked="" type="checkbox"/>		

## **VII. CONCLUSIONS**

The successful implementation of the methodologies of Lean and Six sigma methodologies to decrease the number of accidents occurring in the industry is done by implementation of the methodologies of Lean and Six Sigma in a continuous improvement plan we can achieve six sigma level of perfection in a manufacturing industry. The control phase insures that the sigma level never degrades in an industry and hence with some time the industry can aim for zero injuries and accidents. For that the attitude of workers and management towards safety issues need to be changed in the current scenario.

## **REFERENCES**

- [1] Stephen R. Schmidt and Robert G. Launsby, "Statistical Techniques," in Understanding Industrial Designed Experiments, Volume 1, Air Academy Press, 1994
- [2] Simon, Kerri. "SIPOC Diagram". Ridgefield, Connecticut: iSixSigma. Retrieved 2012-07-03.
- [3] Paul F. English, in Safety Performance in a Lean Environment: A Guide to Building Safety into a Proces,sCRC Press; 1 edition November 21, 2011
- [4] Wilson, Paul F.; Dell, Larry D.; Anderson, Gaylord F. (1993). Root Cause Analysis: A Tool for Total Quality Management. Milwaukee, Wisconsin: ASQ Quality Press. pp. 8–17. ISBN 0-87389-163-5.
- [5] T. Pyzdek, "The Six Sigma Handbook," McGraw Hill Book Companies Inc, US, 2002.
- [6] Osada, Takashi (1995). The 5S's: Five keys to a Total Quality Environment. US: Asian Productivity Organization. ISBN 9283311167.