King Fahd University of Petroleum & Minerals

Department of Construction Engineering & Management

CEM 515: Quality Management

"Implementing the Lean Sigma framework in an Indian SME: a case study "

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Introduction

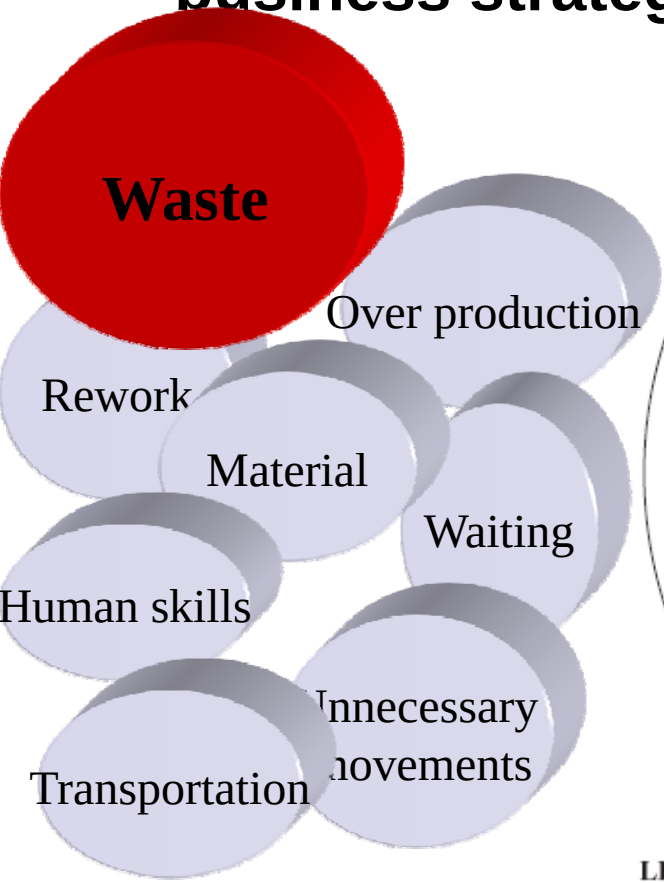
Many industries use either Six Sigma (as process improvement and problem solving approach) or Lean Manufacturing (for improving speed to respond to customer needs and overall cost, eliminating waste and non-value added activities) as part of management strategy to increase the market share and maximize profit.

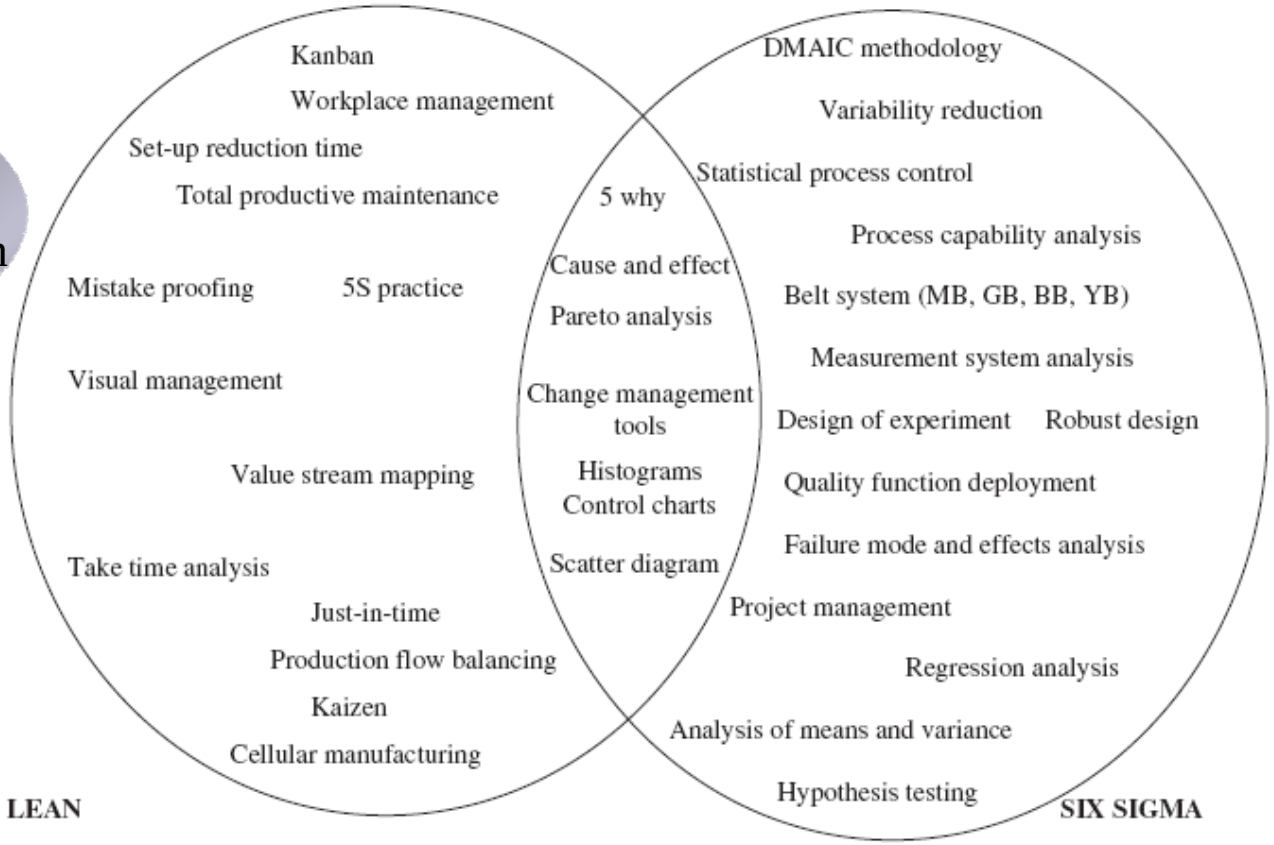
All large companies such as Toyota, Danaher Corporation, General Electric, Motorola, Honeywell, and many others, have achieved dramatic results by implementing either Lean or Six Sigma methodologies in their organization.

Companies have found the most effective way to eliminate the flaws that lead to rework and scrap, and create one unified idea of continuous improvement, is the ***integration of Lean Manufacturing and Six Sigma***.

Introduction

- **The set of tools, techniques and principles that can be used in the integrated approach of Lean and Six Sigma business strategies**





Objective

Implement a Lean Sigma framework into an Indian small- to medium-sized enterprise (SME) in order to reduce the defects which occur in the final product, work-in-process inventory, scrap and rework cost

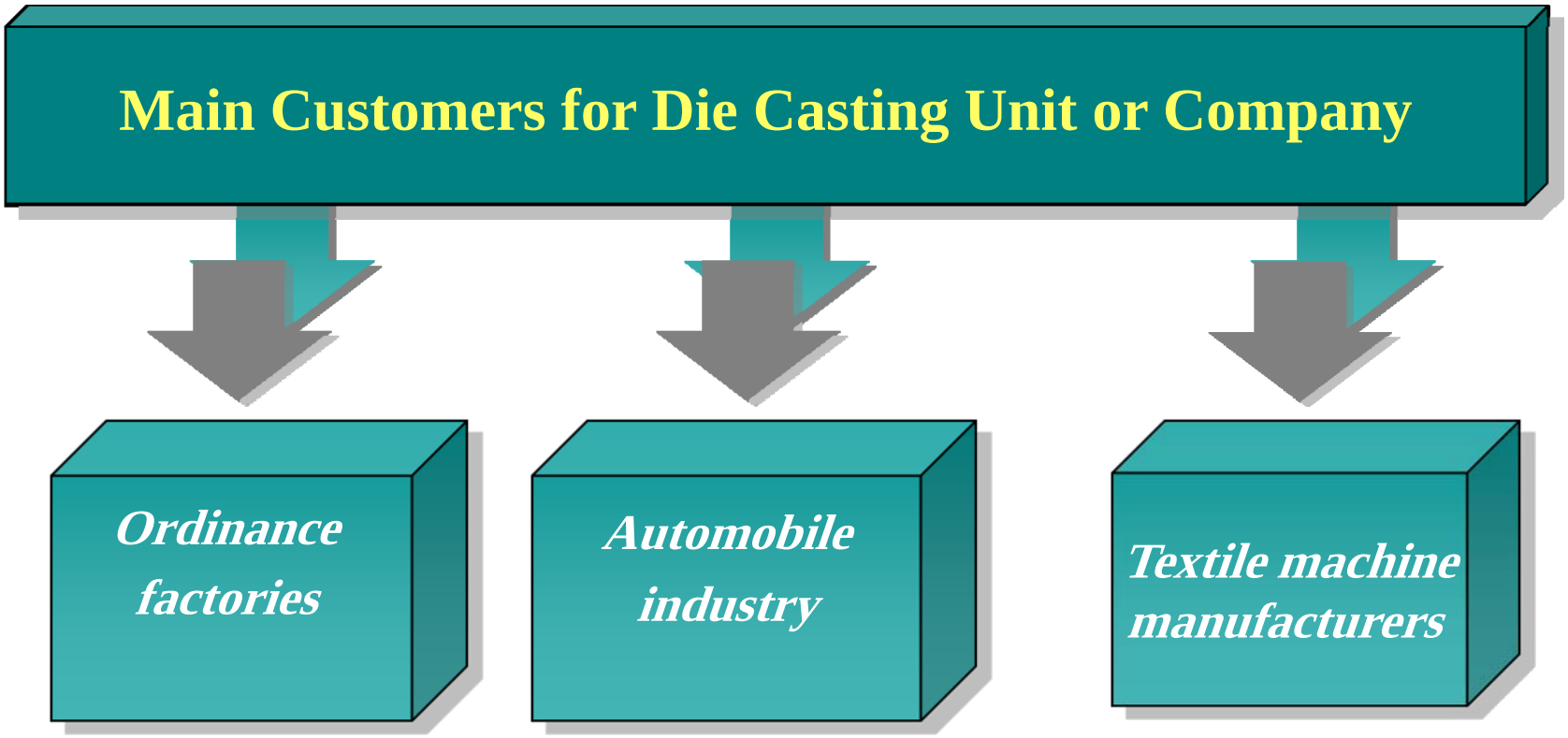
The proposed framework combines Lean tools (current state map, 5S System, and Total Productive Maintenance (TPM)) within Six Sigma DMAIC methodology to improve the outcome or end results and win customer loyalty.

The company was receiving complaints from its customers on crack propagation in the automobile accessories manufactured by the company

Background of the Company

- The die-casting unit was established in 1978 with 150 employees.
- The organization is engaged in designing and manufacturing many types of machined components.
- The company manufactures around 250 000 units of products per year.
- The employees work in three shifts per day, each shift of 8 hours, and six days a week to meet the market demand.

Background of the Company



Actions Before Implementing Lean Sigma

- Top management were proponents of Lean and used to practice TPM, Kaisen, and 5S systems
- Management showed confidence at the beginning of the initiative and supported the quality and production managers with the variety of resources and training required for successful deployment of Lean principles.
- The wish to maximize return on investment and the fear of not meeting the customer demand forced the management to concentrate more on production than on quality.
- This resulted in an increase in work-in-process inventory, scrap and rework cost, and more defects.
- The management was able to meet the customer demands by putting the quality of product at risk. This resulted in a number of customer complaints.

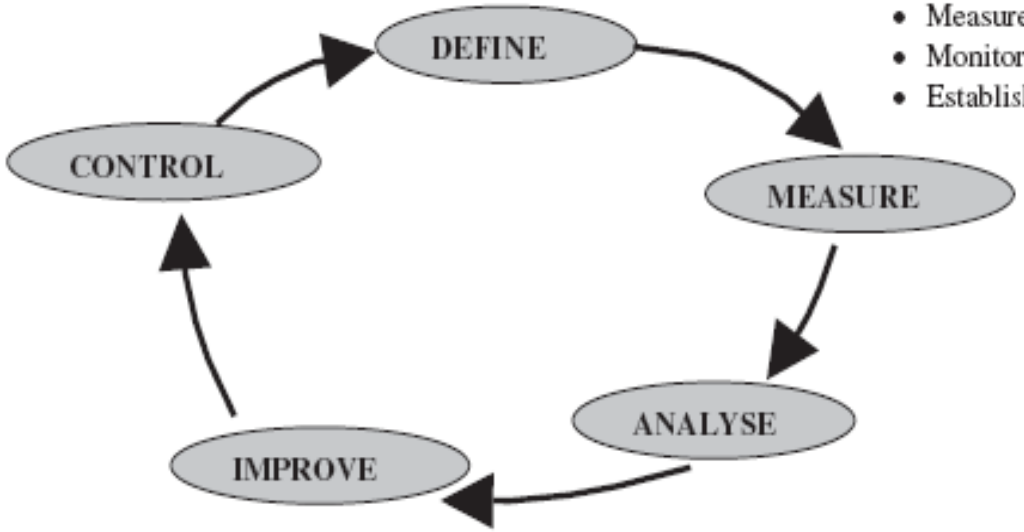
Framework for Lean Sigma Implementation

- Lean tools are used within the Six Sigma (DMAIC) problem-solving methodology to reduce the defects.

Framework for Lean Sigma Implementation

Steps in define phase
- Management initiatives
- Problem definition
- Brainstorming
- Develop big picture map
- Project charter

Steps in measure phase
- Define performance standards
- Measurement system analysis
- Monitoring the process
- Establish process capability



Steps in control phase
- Control chart plotting
- Share the lessons learnt
- Mistake proofing exercise
- Sustainability plan

Steps in improve phase
- Design of experiment
- Screen potential causes
- Discover variable relationships
- Establish operating tolerances
- Establishing 5S system
- Implementing TPM

Steps in analyse phase
- Pareto analysis
- Select CTQ characteristics
- Cause and effect diagram
- Brainstorming
- Identify variation sources

Framework for Lean Sigma Implementation

- ***Define Phase:***

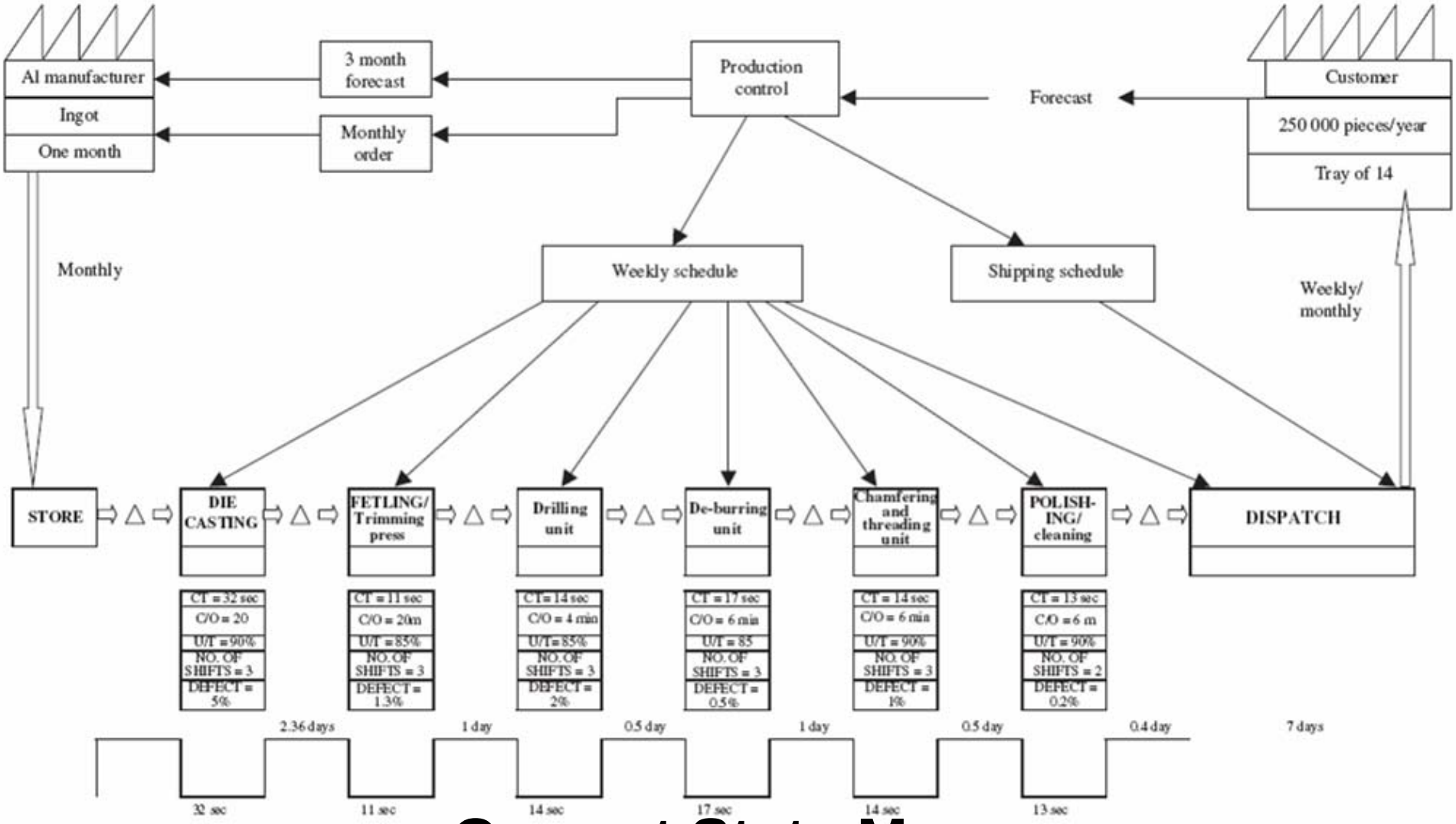
- **Management Initiatives:**

- An emergency meeting was called by top management to discuss the restructuring required in the current practices for enhancing customer satisfaction.
- A team spent hours on the shop floor observing, in order to collect data.

- **Problem Definition:** brainstorming sessions of team members were conducted to identify the root cause of the problem **(CRACK PROPAGATION)** and to reduce the defects.

- **Current State Map:** gives a closer look at the process so that opportunities for improvement can be identified.

Framework for Lean Sigma Implementation



Current State Map

Framework for Lean Sigma Implementation

- ***Measure Phase:***

-The team had been collecting data of defective products for the last 2 years and had identified the critical processes where ***maximum defects*** were occurring.

-Collected data was analyzed and showed that the maximum defects were coming from ***the die-casting machine, de-burring operation, and chamfering and threading operation.***

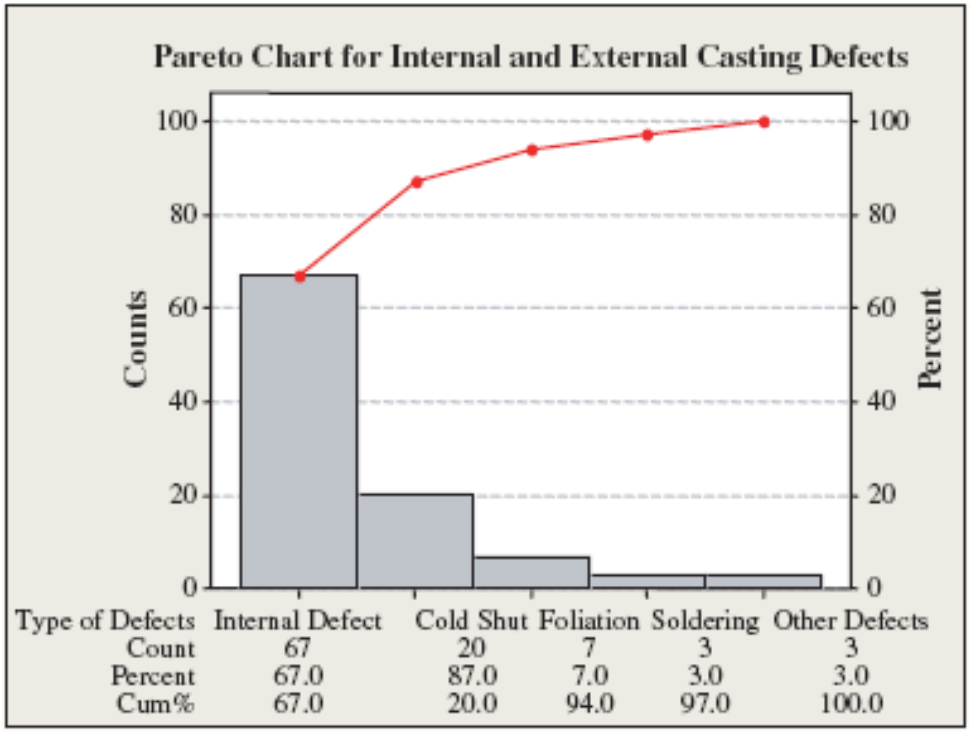
-Goal of the team was to ***increase casting density.***

Framework for Lean Sigma Implementation

- ***Analyze Phase:***

✓ to determine the root causes of defects and identify the significant process parameters.

✓ The ***micro holes*** created inside the casting are due to air or gas entrapment and result in crack propagation due to differential pressure and force created inside the casting.



✓ **Pareto chart**

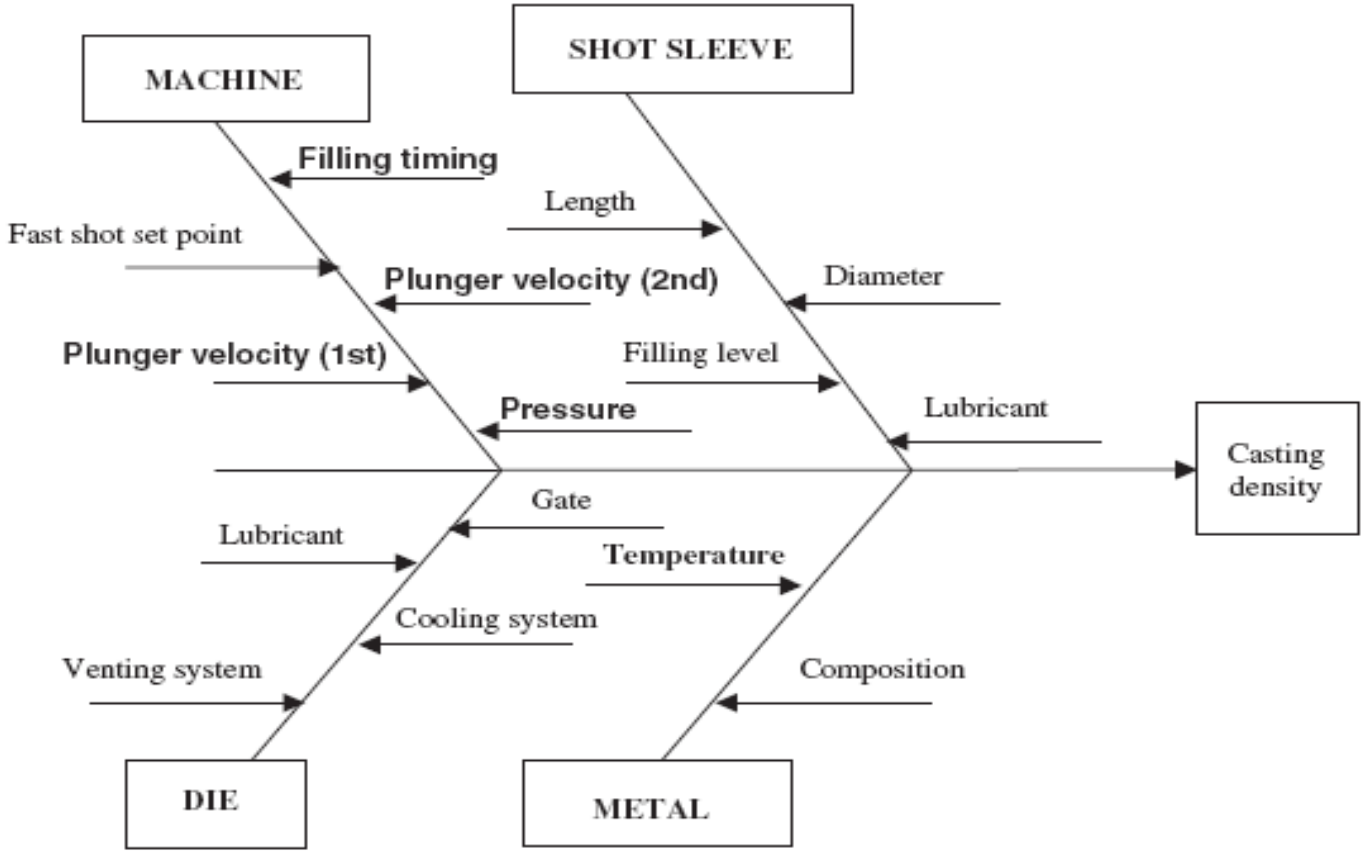
Framework for Lean Sigma Implementation

✓Internal defects are the result of poor casting density.

Total defects from 5/01/04–10/01/04				
	De-burring unit—195		Chamfering and threading unit—81	
Casting—177 (all casting defects)	Casting defects—160	Other defects—35	Casting defects—65	Other defects—16
Defects due to poor casting—402 (out of 523)				
Internal defect			External defect	
Air inclusion	50		Cold shut	10
Shrink holes	80		Foliations	20
Gas holes	130		Soldering	12
Porosity	90		Other defect	10
Total	350			52
Percentage of internal defect—67% of total defect				

Framework for Lean Sigma Implementation

- Cause & Effect Diagram



Framework for Lean Sigma Implementation

- At this stage, it was essential to identify significant parameters so that they are tuned properly to achieve the desired range of casting density

Parameter destination	Process parameters	Range	Level 1	Level 2	Level 3
A	Metal temperature (°C)	610–730	610	670	730
B	Piston velocity 1st stage (m/s)	0.02–0.34	0.02	0.18	0.34
C	Piston velocity 2nd stage (m/s)	1.2–3.8	1.2	2.5	3.8
D	Filling time (ms)	40–130	40	85	130
E	Hydraulic pressure (bar)	120–280	120	200	280

Framework for Lean Sigma Implementation

- **Improve Phase:**

  Design of experiment: the team decided to carry out a 27- trial experiment to identify the significant process parameters affecting the casting density. The casting density is a ***'larger the better'*** type of quality characteristic.

$$\text{S/N ratio} = -10 \log\left[\frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{y_i^2}\right)\right]$$

Factor	A	B	C	D	E
Level 1	7.827	7.803	8.087	7.960	7.923
Level 2	7.951	8.138	8.076	8.038	7.966
Level 3	8.420	8.258	8.036	8.201	8.309

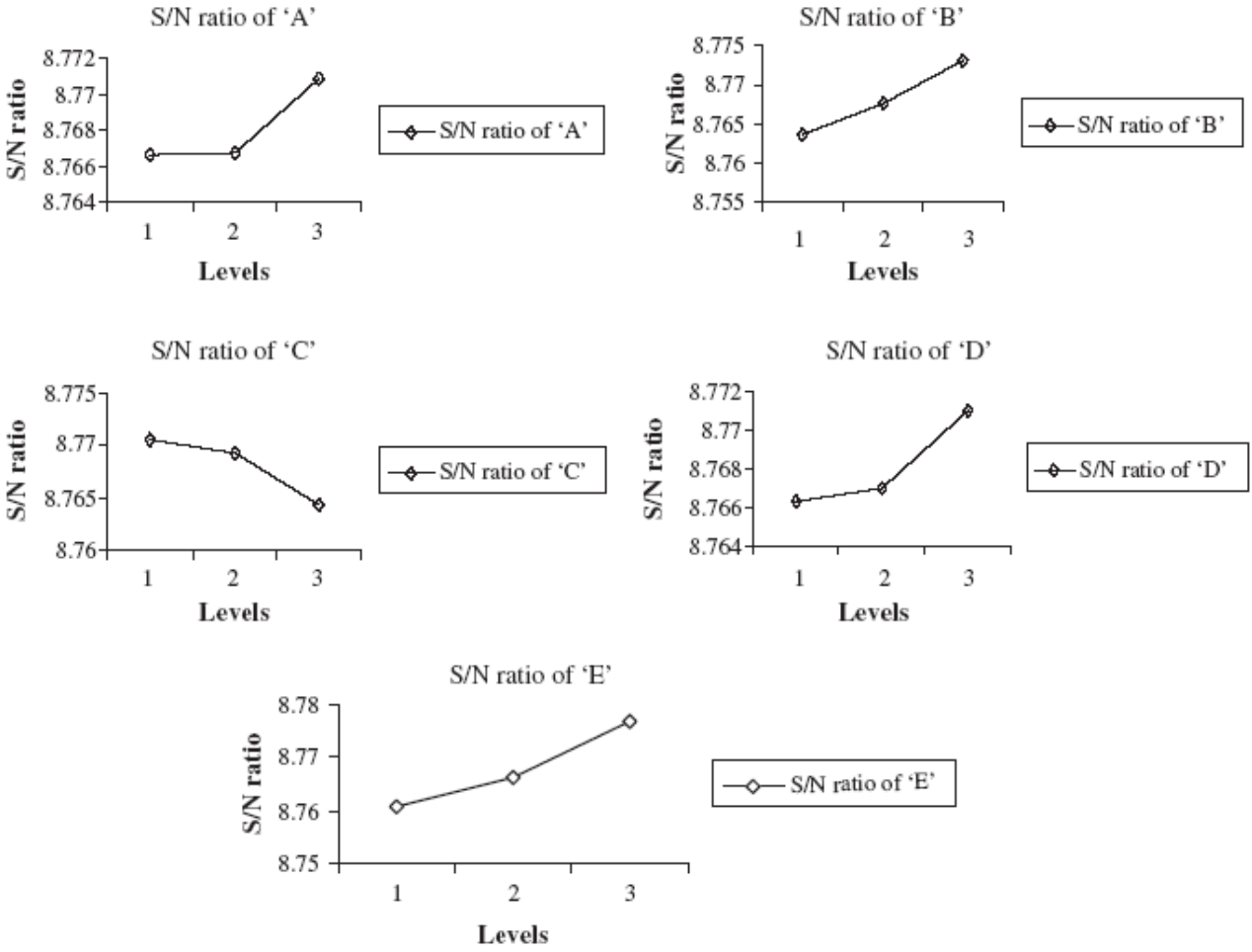
Framework for Lean Sigma Implementation

- 27 trial designed experiment.

Trial no.	A	B	C	D	E	A × B	A × C	B × C	R1	R2	R3	Average	S/N
1	1	1	1	1	1	1	1	1	2.336	2.338	2.441	2.372	7.500
2	1	1	2	2	2	1	2	2	2.339	2.442	2.447	2.409	7.637
3	1	1	3	3	3	1	3	3	2.442	2.505	2.448	2.465	7.839
4	1	2	1	2	2	2	1	2	2.427	2.444	2.416	2.429	7.713
5	1	2	2	3	3	2	2	3	2.545	2.577	2.595	2.572	8.210
6	1	2	3	1	1	2	3	1	2.435	2.336	2.374	2.382	7.538
7	1	3	1	3	3	3	1	3	2.716	2.728	2.701	2.715	8.680
8	1	3	2	1	1	3	2	1	2.346	2.429	2.392	2.389	7.566
9	1	3	3	2	2	3	3	2	2.439	2.442	2.445	2.442	7.759
10	2	1	1	2	3	2	2	1	2.445	2.501	2.487	2.478	7.884
11	2	1	2	3	1	2	3	2	2.439	2.441	2.398	2.426	7.701
12	2	1	3	1	2	2	1	3	2.418	2.381	2.443	2.414	7.658
13	2	2	1	3	1	3	2	2	2.542	2.513	2.504	2.520	8.031
14	2	2	2	1	2	3	3	3	2.459	2.463	2.445	2.456	7.808
15	2	2	3	2	3	3	1	1	2.543	2.585	2.591	2.573	8.212
16	2	3	1	1	2	1	2	3	2.441	2.493	2.502	2.479	7.887
17	2	3	2	2	3	1	3	1	2.594	2.588	2.591	2.591	8.274
18	2	3	3	3	1	1	1	2	2.539	2.542	2.545	2.542	8.108
19	3	1	1	3	2	3	3	1	2.474	2.495	2.489	2.486	7.914
20	3	1	2	1	3	3	1	2	2.603	2.595	2.588	2.595	8.288
21	3	1	3	2	1	3	2	3	2.438	2.473	2.452	2.454	7.803
22	3	2	1	1	3	1	3	2	2.704	2.685	2.692	2.694	8.611
23	3	2	2	2	1	1	1	3	2.640	2.682	2.654	2.659	8.497
24	3	2	3	3	2	1	2	1	2.703	2.698	2.691	2.697	8.623
25	3	3	1	2	1	2	3	3	2.671	2.679	2.685	2.678	8.562
26	3	3	2	3	2	2	1	1	2.726	2.717	2.720	2.721	8.699
27	3	3	3	1	3	2	2	2	2.745	2.747	2.752	2.748	8.785

Framework for Lean Sigma Implementation

- AVG values of S/N ratio for five process parameters at 3 levels



Framework for Lean Sigma Implementation

- **Improve Phase:**

5S system:

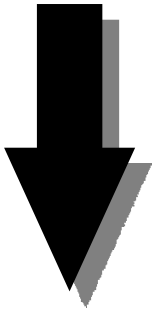
was developed by Toyota to eliminate the hidden factory waste by describing a set of actions to maintain an organized work place.

-Japanese words that describe those actions—Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), Shitsuka (sustain).

-Top management decided to implement 5S system in order to establish a standard approach to housekeeping within the organization and help reduce the non-value added time for employees.

Framework for Lean Sigma Implementation

Some examples of implementing 5S



-The trimming unit was moved nearer to the die casting machine so that time was saved in transportation

- The cleaning of dust particles, grease, and oil from the machines to ensure the health and safety of employees.

Framework for Lean Sigma Implementation

Total productive maintenance (TPM)
was only used for documentation purposes and for attracting customers

Some steps that management used to implement TPM

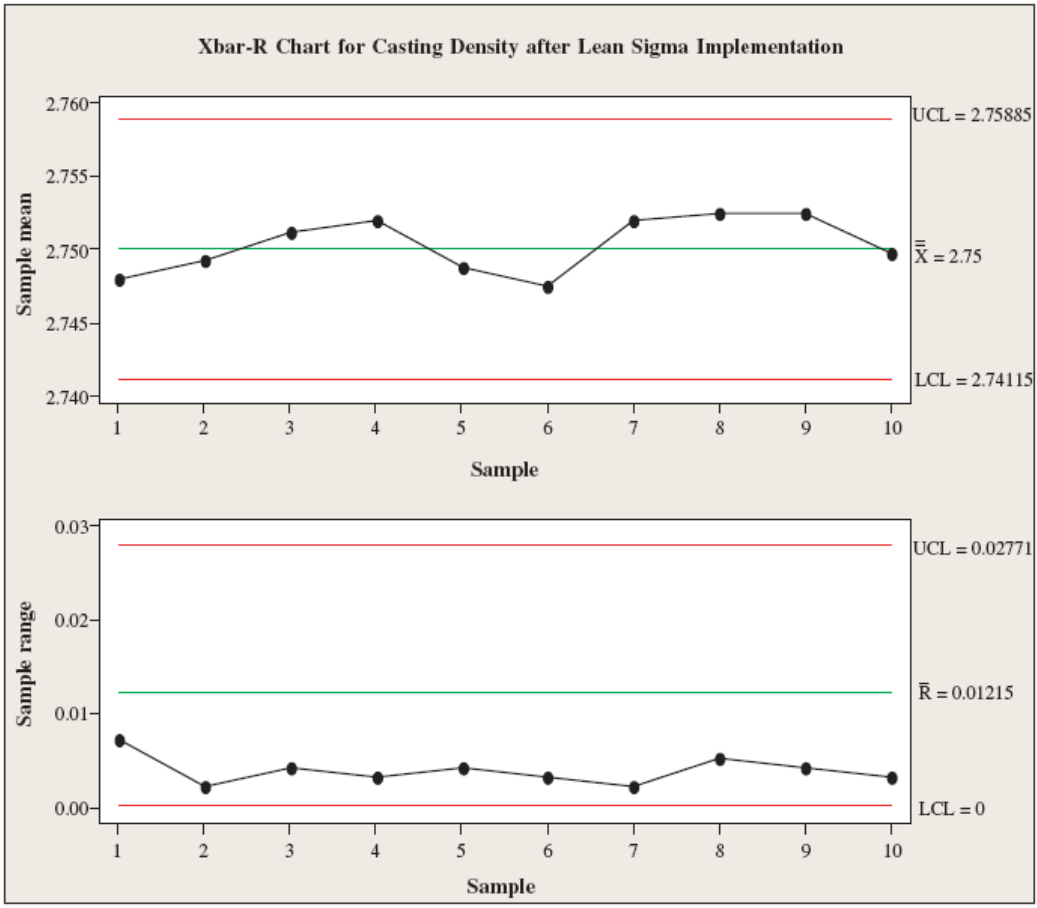
- Periodic maintenance of machines
- Involving employees to achieve zero defects, breakdown, and accidents
- Collection and analysis of data on downtime of Machine.

Framework for Lean Sigma Implementation

- **Control Phase:**

  Sustainability: The main purpose of the Six Sigma is not only improving performance but also sustain it in the long run.

- ★ **Control Chart.**



Framework for Lean Sigma Implementation

- **Control Phase:**

Mistake proofing exercise: **was performed to reduce the number of defects like Human error, malfunctioning of machines, or improper environmental conditions.**

Example: ***Checking the defects at the preliminary design phase so that defects are not passed to the production stage.***

Effectiveness of the Proposed Lean Sigma Framework

- **Implementation of lean sigma framework helped in saving the cost in the process & resulted in huge reduction of defects.**

	Labour $/unit	Operating cost $/unit	Overhead $/unit	Total cost $/unit	Per cent defect before Lean Sigma	Per cent defect after Lean Sigma	Annual impact before Lean Sigma ($)	Annual impact after Lean Sigma ($)	Savings after Lean Sigma implementation ($)
Die casting	0.72	0.97	0.32	2.01	5	0.023	25 125	115.575	25009.43
Trimming	0.80	0.87	0.19	1.86	1.3	0.01	6045	46.5	5998.5
Drilling	0.70	0.82	0.24	1.76	2	0.017	8800	74.8	8725.2
De-burring	0.52	0.77	0.18	1.47	0.5	0.003	1837.5	11.025	1826.475
Chamfering	0.58	0.8	0.21	1.59	1	0.0016	3975	6.36	3968.64
Cleaning and polishing	0.66	0.86	0.38	1.9	0.2	0.008	950	38	912
Total							46732.5	292.26	46440.24

Effectiveness of the Proposed Lean Sigma Framework

- **The implementation of Lean Sigma framework also helped in:**

Reducing machine downtime and accidents

Rectifying the customer complaints

Establishing a standard housekeeping procedure;
& Increasing the confidence level among employees

Effectiveness of the proposed Lean Sigma framework:

improvement of around $140 000 per year in financial terms for the company after the implementation.

Difficulties in Implementing Lean Sigma Framework

Difficulties encountered in implementing Lean Sigma framework:

Convincing top management was the most difficult task as management was not ready to compromise on production to improve the quality of the final product

Resistance from management was also noticed when the team decided to implement the 5S system in the organization

Conclusion

The implementation of the Lean Sigma strategy:

- established best practice within the company and provided the company with a performance benchmark on which they could base future performance enhancement.
- improved the casting density by over 12%.
- significant improvement was observed in the key performance metrics
- savings of around $140 000 per year.
- bringing a cultural change in the company with systematic implementation of the integrated approach throughout the organization.