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Research paper

Effect Of Lean Tools and Techniques for Improving Manufacturing Performance in M/S. Sri Devi Foundry Scenario in Ranipet – Tamil Nadu : A Case Study

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Abstract:

The intention of this study is to examine the implementation of lean manufacturing tools and techniques in the M/s. Sri Devi Foundry at Ranipet. A questionnaire survey was used to discover 14 main input areas of lean manufacturing namely, inventory, material handling, scheduling, equipment, employees,, quality, layout, suppliers, customers, safety and ergonomics, product design, work-processes, management and culture, and tools and techniques. The target respondents were asked to rate the degree of implementation for each of these areas. The average mean score of each area was computed and some statistical analyses were then achieved. In addition, the survey also studied various subjects associated with lean manufacturing such as its understanding among the respondent companies, its benefits and obstacles, the tools and techniques used, etc. The survey results show that many foundries are dedicated to employ lean manufacturing. Commonly, most of them are "moderate-to-extensive" implementers. All the 14 main areas investigated serve as a useful guide to organizations when they are adopting lean manufacturing. In essence, this is perhaps the first learning that investigates the actual implementation of lean manufacturing in foundry production.

Keywords: *Lean manufacturing tools and techniques, foundry, Tamil Nadu.*

1 Introduction

Manufacturers of steel castings in the foundry production industry have always faced high challenges such as rising customer's quality expectation, fluctuating demand, and competition in markets. There is no doubt that these producers are always holding changes and enhancement in their main activities or processes to cope with the challenges. One way to continue competitive in this globalized market is to become more efficient. Lean manufacturing has been getting a lot of attentions in the foundry industry. The special effects claim after implementing it is enormous. Lean manufacturing employs less of everything compared to mass production- half the investment in tools, half the manufacturing space, half the engineering hours and half the human effort in the factory to develop a new product (Womack et al., 1990). It has now become a production technique for many manufacturers to practice. Modest studies concerning lean manufacturing have been completed in M/s. Sri Devi Foundry industry, Tamil Nadu. An examination needs to be carried out in order to estimate how organizations in this practice it. This study was investigated with a focus to examine the achievement of lean manufacturing tools and techniques in the foundry production industry. Diverse issues such as its recognizing among the respondent companies, its advantages and impediments, the tools and techniques used etc, were explored. In addition, the degree of implementation of 14 main practice areas of lean manufacturing was reviewed. This paper investigated with a general outline of lean manufacturing tools and techniques and the key areas that characterize its implementation. This is pursued by an overview of the approach engaged for conducting the study. Findings of the survey together with the results of some statistical analyses that were useful.

2. Literature Review

A. P. Chaple et.al, (2004) studied the principles of lean thinking have been generally established by several manufacturing operations and have been employed effectively across many disciplines. While diverse investigators and practitioners have considered and commented on lean manufacturing, it is very tough to find a brief definition which everyone consents. Different researchers define it peculiarly. Lean manufacturing is most frequently linked with the elimination of seven significant wastes to restructure the effects of inconsistency in supply, processing time or demand **(Shah and Ward, 2007).**

Malihe Manzouri et.al stated **(2014)** that key businesses around the world have been striving to reduce the total cost and wastes across their supply chain to remain competitive in the growing global market. Therefore, an assortment of reliable tools and techniques are primary for decreasing costs and wastes and for providing effective services for customer demands. Worley (2004) described it as the systematic elimination of waste by all members of the company concern from all areas of the value stream.

Liker and Wu (2000) identified it as a philosophy of manufacturing that aims on distributing the highest quality product on time and at the lowest cost. **Hayes and Pisano, 1994** stated that lean as it utilizes less, or the minimum, of everything necessary to create a product or carry out a service. **Shah and Ward, (2003)** demonstrated that the lean manufacturing can be best described as a tactic to deliver atmost value to the customer by eliminating waste through process and human elements. Lean manufacturing has turned into an integrated system compiled of highly interconnected elements and a wide diversity of management practices, including work teams, Just-in-Time (JIT), cellular manufacturing, quality systems etc., **Ratneshwar singh et,al. (2013**) defined that TPM achievement in machine shop and reduce break down time and develop performance efficiency. TPM depend on diverse pillar, like 5S, jishu- hozen, planned maintenance, quality maintenance, kaizen office, and safety, health & environment are put one by one and enhance the quality of product with over all equipment effectiveness (OEE).

According to dinesh seth at.el. Lean manufacturing is the systematic methodology to recognize and eliminating waste by continuous improvements. In this paper minimize the waste in the manufacturing of castings in foundry industry with the help of value stream mapping tool.

Karlsson and Ahlstrom, 1996 and Sanchez and Perez, 2001 identified the purpose of implementing it is to reduce lead time and cost, improve quality and thereby increase productivity. **According to K. Venkataraman (2014)** says that different organizations are implement lean manufacturing in current year for reducing and eliminate waste. The author uses the value stream mapping for reducing cycle time of crank shaft. Various kinds of tools are employed and get benefits, generate a current state map of the crank shaft assembly line. It also produce an upcoming state map for improving process of crank shaft assembly.

Womack and Jones, (1994) defined that lean manufacturing requires that not only should technical questions be completely understood, but existing relationships between fabricated and the other areas of the industry, should also be observed in depth, as should other factors external to the business system.

Wong et al. (2009) demonstrated that the implementation of lean manufacturing can be characterized by an integrated set of main areas or factors. This key region included a wide array of practices which are supposed to be critical for its accomplishment. There are work processes, proper scheduling, equipment, product design, inventory, effective layout planning, material handling, customers, suppliers, employees, safety and ergonomics, product design, management and culture, right quality and necessary tools and techniques . These 14 areas are the subjects of examination in this study and each of them will be evaluated and explained now.

Tompkins et al., (1996) clarified that that material handling is also vital in lean manufacturing because the cost attributed to material handling is estimated between 15% and 70% of the total production operation expenses

Karlsson and Ahlstrom (1996) and Sanchez and Perez (2001) described that transporting components , parts and sub-assemblies not only does not add value to a product, it increases manufacturing lead time. Hence, it is a key waste that requires to be eliminated and said to be steady material flow which moves frequently in small batches will permit a faster replenishment of materials. This will then cut down lead time and increase productivity**. Mortimer, (2006**) stated that the level of equipment support should be given attention in lean.

3. Background of The Study

At current the success of the many foundries industries primarily depends on several factors such as, quality of castings, manufacturing cost, throughput time, maximum yield etc., These factors are hampered due to various defects occurs in the foundry industry. These defects can be repairable that tends to defectives of product that leads to elimination. In worldwide, most of the steel castings suffering due to their rejection of their outputs. Defectives in the castings in foundry industry are often that holds the smooth production. It focuses defective casting products having a high impact on overall industry budget due to casting wastes. Minimization of defects is a must in quality and productivity improvement. Whereas rejection causes waste which generally due to so-called man made mistakes, which is from Pareto analysis. In these consequences casting firms are chosen for research work for elimination of casting waste by implementing 5S lean tool in all departments of castings and DMAIC Six Sigma methodology. This investigate tried to extract the common scenario of Production of Castings in Foundry sector of Ranipet in Tamil Nadu by depicting the existing situation of casting industries.

4. Problems Identified

The steel casting products of foundry industry like Gate valve, globe valve body, swing check valve body, control valve body, butterfly valve body, plug valve body and glands, bonnets, yokes etc. are some of the casting products. These are inspected for defects since this was the important castings for the foundry industry as they had more demand and the profit margin for these values of products is high. Table.1 shows the total number of castings inspected and the number of defectives

Table.1 Defects of Foundry products before implementation of 5S

S. no	Castings	Inspected quantity	Defective items	Rate per casting	Total amount loss per defective casting	Production cycle time per casting (minutes)
1	6” x150 GTV body	1550	80	1250	100,000	180
2	8” x300 GBV body	1500	72	1300	93,600	192
3	3”x900 Control Valve body	702	43	950	40,850	184
4	10”x150 Butterfly valve body	940	23	1400	32,200	170
5	6”x 150 Check valve body	1200	42	860	36,120	180
6	10”x150 Glands	1230	18	1220	21,960	240
7	8”x150 Bonnets	1190	91	1100	100,100	120
8	10”x150 Yokes	764	21	1040	21,840	160
Total		**9,076**	**390**	**9,120**	**446,670**	**1,426**

5. Suitable Lean Tools and Techniques for Chosen Foundry

This paper emphasized that the lean is not only tools and techniques, but it act as a philosophy. It is a ‘way of thinking' and not a device to action these thoughts. Lean viewed as a philosophy. In this study of work, implementation of lean tools and techniques to eliminate key casting wastes exist in the chosen foundry. Such as Pareto analysis and Five S (5S).These tools are described below:

Pareto analysis: In general, the Pareto principle, applied to quality of castings products considers that the maximum of the quality losses are mal-distributed in such a way that a “vital few” defects at all the time contain a high percent of the overall cost of quality losses. These defects may occur due to low quality casting materials or careless behavior of employee. In the global manufacturing, due to competitive nature of the business market, many castings foundries have awaked to implement for various types of lean tools and techniques to reduce the casting wastes to eliminate the percentage of defect. Pareto Analysis requires finding dissimilar casting wastes and classifying them according to their importance.

5.1 DMAIC concept

Six Sigma is an organizational improvement strategy used to enhance profitability, to drive out waste, to decrease quality costs & improve the effectiveness and efficiency of all operational processes that meet or exceed customers’ needs & expectations [8] Mostly both methods are used for managing the existing process scenario. The determination of prospective reasons for detailed problem through cause and effective diagram concept. Adaptation of short term solution of both Six Sigma methodology and cause and effective diagram concept for long term of casting foundry problems.

Five S (5S): 5S is a fundamental tool to generate continuous improvement process in foundry industries and represents a transformation in five steps of a product, which is distinguished by greatest efficiency at the micro level and minimum loss. The most important factor which is under the accomplishment and maintains the compliance is presented for each 5S stage [7]. The system produces a non stressful environment where all items are easy to find and without any deviation from the normal conditions become obvious by visual management methods. At same time, 5S techniques maintain quality, reduce the movement and promote a major costs reduction by eliminating the wastes and provide the best framework for development throughout the industry.

6. Research Methodology

This study aims about eight types of lean wastes of the selected casting manufacturing industry located at Ranipet in India. Lean tools and techniques are employed to minimize wastage of the existing steel castings scenario of the selected foundry. The information and data collected were scrutinized and properly organized put together so that further study and analysis could be performed. Quantitative data were investigated by using graphs and tables. Different kinds of information were given as a profile-waste matrix. Based on table 1, analysis has been shown by Pareto Diagram. Based on profile waste matrix, Pareto analysis helps to identify 83% of castings waste occurs due to human mistakes. Through groundwork analysis the most of defective castings products occurring in cutting of unwanted riser runner and gating systems in knocked castings, heat treatments of raw castings, blasting operations of shots as well as sand blasting of castings, inspection yard and non-destructive testing of castings, repairable castings by welding, fettling operations and, packing and finishing section among all sections in chosen foundry industry. The collection of data is further analyzed and technique utilized for problem solving through DMAIC of Six Sigma tactics and for attaining productivity excellence. Mostly employee’s careless behavior can be reduced by 5S lean tool. Therefore this study minimized casting defectives by implementing 5S. Finally results from the overall analysis for foundry industry is given and proper guidelines are provided for continuous improvement (minimization of defective and manufacturing lead time, waste minimization) of the foundry.

7. Findings and Analysis

Collection of data and information was gathered some past record from the arc and gas cutting , shot and sand blasting of castings, heat-treatment of raw castings , removal of unwanted gating systems, finishing of castings by swing frame and die grinding methods, inspections of castings by destructive and non-destructive methods of sample and packing sections of the chosen foundry indsutry and through the observation made of the foundry manufacturing floor. The information as well as data has been collected from production supervisors, managers and chief executives of foundry industry through the questionnaire, physical observation, telephonic contacts and interview. Finally, all data has been analyzed by using tables, graphs and some tools such as Pareto analysis, cause and effective diagram, DMAIC approach and 5S.

7.1 Findings of wastes in the Foundry

A total of 9,076 different types of castings were checked and 390 castings were found defective and its 4.3 % defective. This study has recognized that how to minimization of waste can be employed in lean manufacturing to improve the manufacturing performance of casting foundry industry. This work adds to an application guideline for the assessment, and reduction of lean wastes in garment industry. During this phase, after discussions with the production manager and line supervisor’s data is collected independently. Several lean wastes are determined which affects the production process of the firms, after visiting the foundry industry. According to lean concepts these foundry castings wastes in chosen firms are discussed as follows:

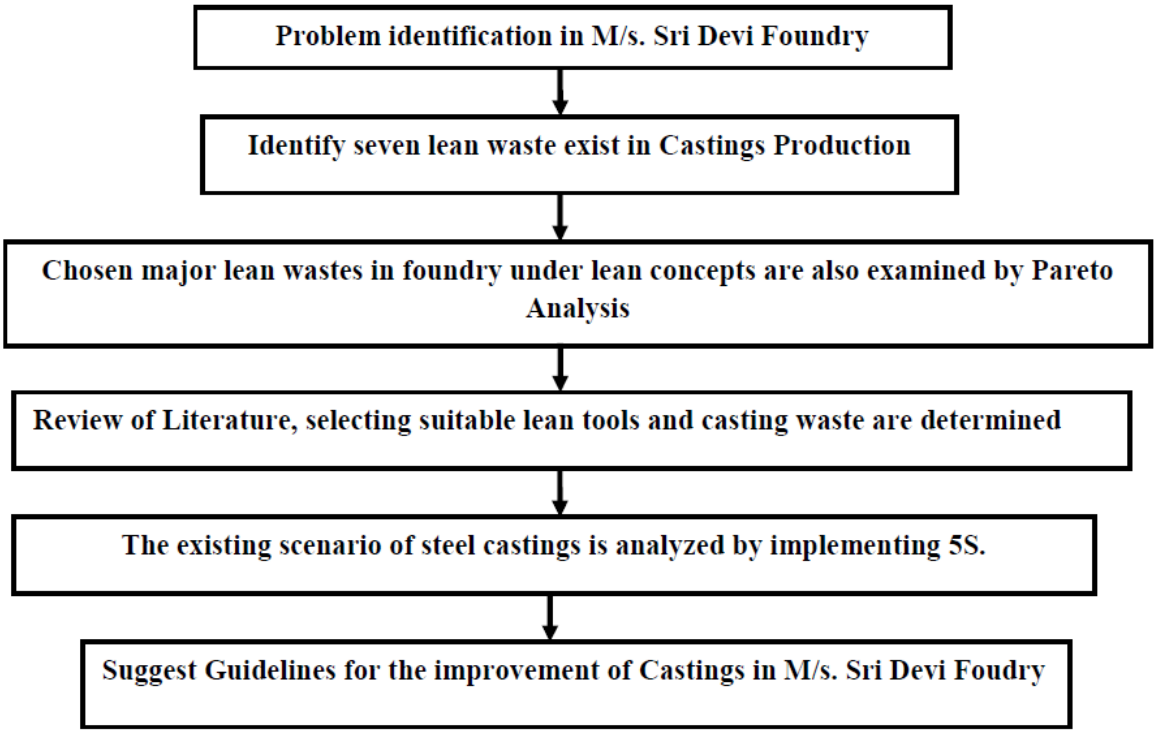

Figure 1. Steps involved in details analysis.

7.1 1. Overproduction:

Overproduction creating more than that is necessary by the subsequent process. Various numbers of production managers and supervisors assumes that a casting waste is caused by quality problems and manufacturing extra products would make certain that the client order is fulfilled. Surplus castings manufacturing products possibly will be sold with cheap prices at the fiscal year end of the industry to match the finances for the subsequent year's inventory . In each production line, rejections of products occur in foundry industry. The cost of overproduction for business firms may be various dimension. Hence, the management always fixes the production objective more than the buyer's necessity.

7.1.2 Waiting

Waiting takes place in foundry industry because of various non value added activities among production processes. Practical schedule is to be set for the minimizing of some percentage of waiting which occurs in the casting manufacturing firms. In several castings, the waiting is prone to take place in various areas like samples, stores, cutting yard, heat treatment yard , cutting, fettling yard, inspection yard, non-destructive testing yard, finishing and packing sections and administrative office in foundry. This contains waiting for material, equipment, tools and information, etc. A number of delays are because of waiting for the course, machines and equipment break- down periods, service time as well as wait time for the approval. The cause of the delay in processing is uncertain and the subsequent machines to be equipped or additional aid to finish the course. This surplus time allotment for the employees to do the increases the castings the overall wait time and delay in the process. Many times it has been found that casting manufacturing employees are waiting in various foundry sections and other accessories. This type of waste is also generated due to breakdown of machine and power failure.

7.1.3. Transportation:

Transportation is defined as dispatch to and from outside the foundry industry. Transportation of completed manufacturing castings are normally made by a suitable methods. The casting process in most of the foundry industries are facing major impact of lean. Every interval in castings production that causes waiting time has the possible to allow work in progress to accumulate. Lean demands that the casting products to be shipped directly from the vendor to the particular location where it will be used.

7.1.4 Inventory

Inventory control is one of the major key elements in casting manufacturing because of its maximum expense. More research papers suggest that 63% of all wastes occur in foundry industry due to inventory.

7.1.5 Excess motion:

Unwanted motion of worker in casting manufacturing industry will result in time lag, waste of human effort and increased cost of the finished castings. Excessive motions in the manufacturing environment will reason delay of manufacturing and a lot of troubles. Unnecessary motions primarily for undocumented work technique and poor flow. The key observable difficult in casting industry is the reducing the operational efficiency. Therefore, time loses in lifting, moving from one place to another place in castings, identifying and retrieving. Inconvenient manufacturing area for position of product of castings inputs also leads to a waste of energy time and labor force while arranging and identifying.

7.1.6 Defect:

Rectification, salvages, reworks and rejections of casting in foundry is the general scenario in sections of foundry. Every day 1:7 products of castings are found to be defective in foundry industry. Mostly defective materials in foundry may add supplementary changes in design, quality and nature of work. Normally 84 % of the output is counted as accepted level by quality department in foundry industry and remaining 26 % of the output is counted as defect items and rejected by the customer. Due to poor quality of materials, machines and equipment, unnecessary processes, human errors and design errors, defect occurs. Minimum number of production processes may attain good quality in each time. Defective items can cause both indirect and a direct cost occurs in foundry industry. The costs arises from defective items may be a problem to foundry manufacturing industry.

7.1.7 Over Processing:

The majority of the castings processes are essential to the lean concept which tends to minimize the casting wastage. Several research articles indicate to the over processing is more significant to reduce the wastage in foundry. As a result, it is essential to focus at all

operations in foundry firms as potential waste.

7.1.8 Under utilization of People

Labors are the key significant assets when it comes to ensuring that foundry industry accomplishes their targets. Mainly employee turnover is one of the critical factors that guide to loss in productivity of a casting manufacturing industry. Foremost problems in foundry industry are mainly related to machines and equipment and employee versus.

8. Findings and Analysis

8.1 Findings and Analysis of DMAIC through

Cause and effective analysis: Most of the foundry industry followed DMAIC approach elimination of their defects and attaining excellence of the product. In several production industries adapted to be structured DMAIC concept for their continuous improvement and attaining for more profit. DMAIC (Define, Measure, Analyze, Improve and Control) of six sigma methodology is one of analytic tool to root cause for existing manufacturing scenario for eliminating the maximum percentage of defectives.

8.1 Define

In selected M/s. Sri Devi foundry industry is attaining 4.30 % of defective castings and suffered lot due to rejections. In order to eliminate these defectives, by the study under literature review, the researcher suggests for implementing the DMIAC concept. The quality of castings is evaluated through process map (SIPOC) output.

8.2 Measure

In this stage understanding of existing scenario of chosen foundry industry to initial calculation. The defective castings of gate value body, globe valve body swing check valve body, ball valve body, butterfly valve body, bonnets, yokes and impeller castings were measured .

8.3 Analysis

In this stage deals the optimum solution achieved through root cause of the casting processes. According to Cause and effect diagram found the solution for defective castings.

8.4 Improve

In this stage is to determine the solutions for preferred foundry industry problem. This research accomplished the elimination of substantial amount of casting defectives through brainstorming with the help of literature review.

8.5 Control

In this stage controlled casting defectives nearly this works eliminated the castings defectives from 4.30% to 2.37% for profit earned Rs 15,75,959/- in preferred foundry industry by lean manufacturing tools. In table- 3, shows the percentage of defectives found in quality department before and after implementation of lean tools and techniques.

9. Findings and Analysis Of 5s

The concept5S has its origin in Japan in the later part of 20th century. 5S can be applied to any foundry industry in all divisions as a starting point of improvement actions. A variety of studies have been carried out throughout the year describing the significance of implementing 5S in industrial sector.

Table 2: Profile-Wastes matrix in casting manufacturing Industry

Types castings waste	Causes	Responsibilities			
		Man	Machine	Material	Others
Over production	Unleveled scheduling	✓			
	Unbalanced work load	✓			
	Lengthy process step		✓	✓	
	Misuse automation	✓			
Defect	Shrinkage	✓		✓	✓
	Gas holes	✓		✓	✓
	Sand Inclusion	✓			
	Pin holes			✓	✓
Transportation	Large batch size	✓	✓	✓	
	Poor plant layout	✓	✓	✓	
	Poor understanding of the process flow for production	✓	✓	✓	✓
Inventory	Unleveled scheduling	✓		✓	✓
	Poor market forecast	✓			
	Un balanced work load	✓		✓	✓
Over processing	Styles changes without process changes	✓			
	Lack of information about process	✓			
	Customer true requirement not properly defined	✓			✓
Motion	Unplanned equipments and Tools for Work Place	✓		✓	
	Lack of space in foundry industry	✓			

	Large items located on upper or lower shelf	✓			
Waiting	Time taken for signature approval	✓			
	Improper arrangements of machines and equipments for process sequence	✓			
	In adequate servicing of machines	✓			
Under Utilization Of People	Challenge of the production manager is to allocate right responsibilities	✓			✓
	Challenge of the production manager is to allocate right authorities	✓			✓
	Whether technique used for avoiding under utilization of the people is the scheduling of their jobs	✓			✓

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Table 3. Percentage of defective castings before implementing DMAIC and 5S concept

Areas	**Causes**	**Solutions**
Man	Lack of interest	Improve supervision
	Improper training and unskilled operator	Skilled operators requirements
Molding Machine	Excessive pulley tension	Maintain proper pulley tensions
	Cleaning not in the drum	Should be clean at every 4 hours once.
Method	Improper dowel pin location	Alignment should be checked
	Dowel pin inserted is improper	Ensure the dowel pin position
Material	Raw materials and compositions improper	Avoid moisture raw materials Ensure proper composition standard.
	Mould sand quality not good	Ensure the fine grain size ASTM standard

5S is a technique which simplifies the casting manufacturing work environment, eliminates the foundry wastes and non-value added activities while reducing defectives, and improving productivity and safety. Measuring the effect of 5S system in performance development of a small scale industry. The 5S methodologies focus on effective work place of firms and standardized work procedures. Each of the five (5S) indicate the first letter of five Japanese words like Seiri, Seiton, Seiso, Seiketsu, and Shitsuke that outline the steps involved in better workplace environment and good housekeeping.

Quality and Productivity Improvement: After implementation of DMAIC and 5S, the percentage of defective castings are reduced and substantial improvement of good quality of castings are being produced. Various defects are shown in **figure** before implementing lean tools and In order to eliminate defects of the castings, m**odification of gating systems, and processes are included which shows an improvement of better casting yield performance as shown in figure.**

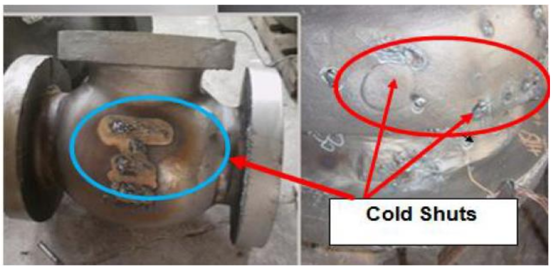

Fig (a)

Fig (b)

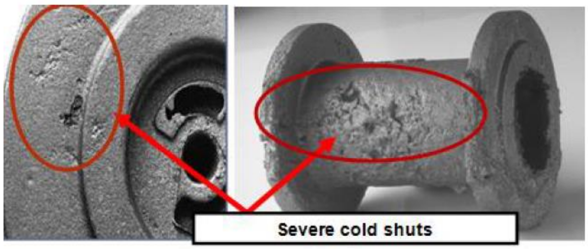

Fig (c)

Fig (d)

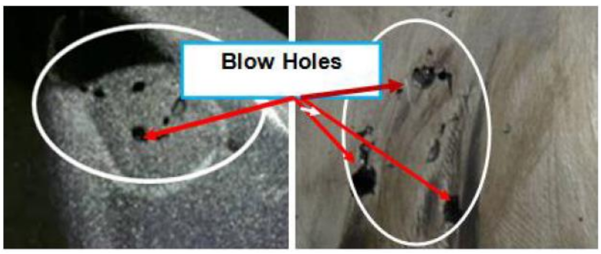

Fig (e)

Figure .2 (a),(b),(c), (d), (e) Various surface and Sub - surface Defects of Casting before implementing DMAIC and 5S Approaches.

Figure 3 Poor casting yield noticed before modification of gating system.

Figure 4. Better Casting yield after modification of gating system

10. Conclusions

This case study research has extracted an overall scenario of the Casting of the chosen M/S. Sri Devi Foundry industry for minimizing manufacturing defectives.

- In this association lean manufacturing concept is implemented as a new concept of manufacturing in the castings. From 5S analysis, it has been found that a lot of unnecessary products exist in the foundry industry like casting waste material and unwanted tools and equipment.
- From DMAIC methodology substantial amount of casting defectives are eliminated. Sometimes casting materials are not put away directly after work.
- The foundry worker will feel more comfortable at work and the continuous improvement actions will tends to minimum waste and good quality of casting product which improves the foundry's competitiveness and profitability. Earlier to 5s analysis and DMAIC methodology various types of lean wastes were determined and the causes in earlier article discussed about implementation of Cellular manufacturing and team work concept.
- Every employee feel very pleasant about where they work, the effect on continuous improvement can tend to minimize the foundry waste, minimize the defectives of casting materials from 4.30 % to 2..27%, and some amount of motion and also lead times is also reduced by implementing 5S concept.

11 Recommendations for Future Work.

i) Dust and dirt of pollution of castings manufacturing products occurred in many lines of production, but all the workers didn't wear mask, so they cannot work comfortably in this situation. As a result, labor productivity as well as productivity of the workplace is reduced.

ii). To overcome the human mistakes by following 5S concepts and shortage of employee by Calculates approximately the optimum numbers of operator wants per day.

iii). It should be checked whether foreign iron particles present in the foundry sections and ensure dust and dirt-free environments in the industry.

iv) Proper and adequate training could be provided to the unskilled employees so that they should have superior knowledge and consciousness about the manufacturing process of various molding and melting machines in foundry.

v). Daily 5S housekeeping should be adopted and sustained properly in foundry industry for effective utilization of workplace and for continuous improvement.

vi) Proper infrastructure (lighting arrangement) is made for foundry and melting operators.

vii). A proper on-time maintenance system should be provided for various machines in Foundry so that it is possible to reduce machine breakdown time.

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