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Implementation of Lean Manufacturing in Foundry Industry for Reduction in Time as a Waste Using Sustainability

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Abstract: During the last decades, environmental issues are receiving a continuously increasing amount of attention in society at large and within many markets and supply chains in particular implementation of environmental strategies in manufacturing companies. The manufacturing sector is responsible for about 33% of the primary energy use and for 38% of the CO_2 emissions globally. the increasing price of energy and the current trend of sustainability have exerted new pressure on manufacturing enterprises that have to reduce energy consumption for both cost saving and environmental friendliness, as well as Life-Cycle Inventories initiatives. Energy efficiency becomes a driver for manufacturing industry. The objective of this research is to provide a clear relation between lean and sustainability by using concepts of lean and to demonstrate how lean concepts can be used into foundry industries. By secondary data relations between the categories (lean, sustainability, and foundry) was made where a conceptual model of 'Lean Manufacturing' was provided. The concept was further supplemented by interviews.

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I. INTRODUCTION

The climate change indirectly effects biodiversity, sea levels etc. All evidences are pointing on the fact that human activity is responsible for the climate change [1]. The birth of the 'Lean Manufacturing' can be traced back to Toyota's desire to become a learning organization. This desire to learn and the strong external pressure Toyota faced in surviving and growing as an organization after the events of World War II led to the development of a disciplined process-focused production system now known as the TPS or Lean. An organization to be successful in its rapidly changing external environment, its capacity to learn must exceed the rate of change imposed on it. The views that learning is important to the survival of organizations and is a significant source of competitive advantage are also prevalent in the workplace learning, organizational learning, and knowledge management literature.

The main reason for companies to apply lean is often based on a negative incentive, like a financial crisis .But why wait for some crisis to reap lean's many benefits? Benefits such as: fundamentally increasing competitiveness by utilizing resources more effectively, while improving quality, reducing cost, and increasing responsiveness. These improvements are achieved by a philosophy of continuously attacking non-value adding actions, or 'waste'. This waste elimination is an important commonality with sustainability.

Due to environmental changes, sustainability the integration of environmental, social, and economic goals is a huge topic in business these days, corporate sustainability will become ever more important to competitive success [2]. Going the proactive 'green' way can even be profitable. Especially when lean, as a proven management system can support the sustainability cases. But also the other way around: when a company's sustainability goals are considered along the lean path, lean can be deployed even more usefully.

Lean is the relentless pursuit of adding value for the customer, waste elimination, and continues improvement from a standard at the point of activity by everyone, everywhere, everyday [3]. The 14 principles are listed below [4]:

- Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.
- Create continuous process flow to bring problems to the surface.
- Use "pull" systems to avoid overproduction.
- Level out the workload.
- Build a culture of stopping to fix problems, to get quality right the first time.
- Standardized tasks are the foundation for continuous improvement and employee empowerment.
- Use visual control so no problems are hidden.

- Use only reliable, thoroughly tested technology that serves your people and processes.
- Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.
- Develop exceptional people and teams who follow your company's philosophy.
- Respect your extended network of partners and suppliers by challenging them and helping them improve.
- Go and see thoroughly understand the situation.
- Make decisions slowly by consensus, thoroughly considering all options and implement decision rapidly.
- Become a Learning organization through relentless reflection.

Green and sustainability should be interpreted as doing things that are only beneficial for the environment but it should rather be seen as doing things more environmental friendly [5]. Doing things sustainable is doing things with aspects on the economic side, the social side and the environmental side. This is presented by the 'triple bottom line' [6]. The common definition of sustainable development is the definition presented in the UN Conference 1987 which is 'Developments that meets needs of the present without compromising the ability of future generations to meet their own needs' [7]. The nine top drivers for corporate sustainability are shown in fig. 2 [8].

Fig. 1 Triple Bottom Line [6]

Fig.2Drivers for Corporate Responsibility and Sustainability [8]

II. SUSTAINABILITY AND INDIAN FOUNDRIES

The foundry industry in India is largely in MSME category [9] and due to pressure of margins, lack of awareness, high cost of capital, modern design, manufacturing tools and equipment is not able to invest in modern technology [10]. Therefore, going forward and to sustain the growth in this sector, the stakeholders need to focus on various aspects such as the ones mentioned below. The government has to be a facilitator for having policies to support ease of doing business and create supporting infrastructure and strengthen institutional support. The Indian economy owes a major part of its growth to the 26 million Micro, Small and Medium Enterprises (MSMEs) that provide employment to 60 million people. There are around 5,500 foundry enterprises in India, clustered in 47 urban locations, 90 % of them being micro and small enterprises (MSEs) [11]. The foundry sector faces a number of sustainability challenges, including energy consumption, and environmental and Occupational Health and Safety impacts. But a new project - Scaling up Sustainable Development of MSME Clusters in India - is working to address these sustainability challenges and enable the adoption of sustainable environmental and social business practices.

Global Reporting Initiatives (GRI) is helping foundry-sector companies in India to start producing sustainability reports in order that the numerous sustainability challenges that the sector faces – from energy consumption to environmental and Occupational Health and Safety impacts – can be measured and addressed [12].

III. RESEARCH METHODOLOGY

The systematic process of collecting and analyzing data in order to increase our understanding of the phenomena on with which we are concerned or interested [13]. The research is the gathering and presenting of reliable information. The research is an analytical way of arguing a point using facts, details, examples and opinions as support [14]. Research can be divided into two categories, namely quantitative and qualitative research [15].

A Types of Research

There are two types of research mainly –

1. Qualitative Research

Qualitative research can further be divided into two types [13] -

- Descriptive survey methods: This data is obtained by observations and is also known as the normative survey method.
- Historical survey methods: Reviewing and analyzing literature or documents in an attempt to solve problems that are historical in nature.

2. Quantitative Research

Quantitative research can further be divided into two types [13] -

- Analytical survey method: This is when statistical analysis is done on data that was obtained through quantitative techniques.
- Experimental method: Data is collected by comparison of a group under controlled conditions with a group that is under experimental conditions. The effects of the change in condition are analyzed.

B Data Collection Method

The following methods for collecting data are available [16]: -

- Observation: The researcher unobtrusively observes the subject's behavior without active participation.
- Experiment: The effects of changes that are manipulated and controlled by the researcher are observed in laboratory and field studies.
- Survey: Conducted through interviews and questionnaires. They are the most common method of collecting data.

A survey therefore allows the researcher to obtain data in order to determine the outcomes of events. According to data collection instruments for surveys, are Personal interviews, Telephonic interviews and Postal survey [17].

This study will apply the descriptive / normative survey using questionnaires for collecting data by personally interviewing the person from the various foundry industries. The data collection process has the following benefits:

- It is perceived to be anonymous and is less time consuming than the other methods.
- The data can be obtained within a limited time period.
- The data is relatively easily captured on computer.

C Development of Questionnaire

The aim of the questionnaire is to obtain information that will support the study. The following considerations must be taken when setting the questionnaire [18]:-

- It must be only long enough to elicit the information that is needed.
- The language that is used must be clear and concise.
- There must be no assumptions inferred in the questions.
- There should be no indication given on what the preferred answer would be.
- Incorporate questions that will verify respondents' standpoints.
- Know before-hand how the responses are to be coded.
- Ensure the respondent's duty is easy.
- Instructions must be clearly stated.
- If there are any items that are unclear, clearly explain the reason why they were used.
- Ensure that questionnaires are attractive and expertly done.
- Conduct a pilot test.
- The final product must be carefully scrutinized.

D Layout of Questionnaire

The layout of the questionnaire was designed to ensure it was easy to complete and easy to analyze the data. The following components that are used [19]:-

- Title
- Introduction to provide assurance of confidentiality and anonymity
- Instructions to completing the questions
- Demographic data of respondents
- Core data: the main focus of the empirical study
- Closing remarks: thanking respondents for their participation

The questionnaire was subdivided into the following parts:-

Section A: Biographical Information

This section was designed to extract biographical information regarding the respondent's name, company name, and department with title, assurance of confidentiality & anonymity, instructions to completing the questions.

Section B: Personal info and interest

This section was designed to get some company related data (Products, Product & Process architecture and organizational strategy) [20] and to determine whether or not the operational area or department actually implemented elements of the Lean Manufacturing. This section also contains the questions to check the interest of Sustainability.

Section C: Before Implementation of Lean

The objective of this section was to determine the reasons for not implementing any Lean initiatives in their environment by certain operational areas. In addition, this section will assist with the feedback obtained in the remaining sections of the questionnaire.

Section D: After Implementation of Lean

This section of the questionnaire covers the theoretical components discussed in Chapter two and in Chapter three. The respondents will answer questions relating to the Lean implementation, elements of basic stability after the implementation and other components of the Lean system.

E Response Rate

Thirty questionnaires were analyzed by visiting individual industry for the purpose of the research explained. A response rate of 83.33 %was realized with 25 of the 30 questionnaires being returned for the purpose of analysis as shown in table 4.1. The Response Rate calculated as –

Response Rate $=\frac{Analysed\ \ Questionaries}{Total\ \ Questionaries\ \ \ Sent} X100$

IV. DATA COLLECTION AND ANALYSIS

The survey was performed in the 30 different foundries. The results of the survey are consolidated and analyzed. The data was analyzed and interpreted following the questionnaire structure.

A Analysis and interpretation of Personal Info. & Interest

In this section respondents were asked to provide information about their end use market, product and process architecture, strategy of organization, awareness of lean and sustainability. Each of these categories will be analyzed and presented.

1End use market

The graph of End Use Market is shown in fig. 3. The graph indicates that a large percentage of end use market present in Machine Parts which is 19%, and some lower % of end use market organizations are food processing,
textile machinery and sugar industry items.

2 Product Architecture

The fig. 4 shows the percentage graphical representation of product architecture. The graph indicates that maximum of 48 % industry follows the Daily production product architecture and small lots product architecture is followed by only 24 % of industries.

3 Process Architecture

The fig. 5 shows the percentage graphical representation of Process architecture. The graph shows that maximum of 44 % industry follows the Standardized products process architecture and Standardized assembly products process architecture is followed by 12 % of industries. Product architecture of these types of industries is very straight to the production, they work for daily production, they set their goals in such manner that this production must be achieved daily; anyhow they can achieve it.

4 Awareness of Lean and Sustainability

The fig. 6 shows the percentage graphical representation of Awareness of lean and Sustainability. This question asked for checking the awareness of the lean and sustainability. The graph shows that maximum 20 % people knows about the lean and they also taken training on the various lean tools, and knows about the various other such improvements techniques but there is lowest amount of awareness regarding sustainability.

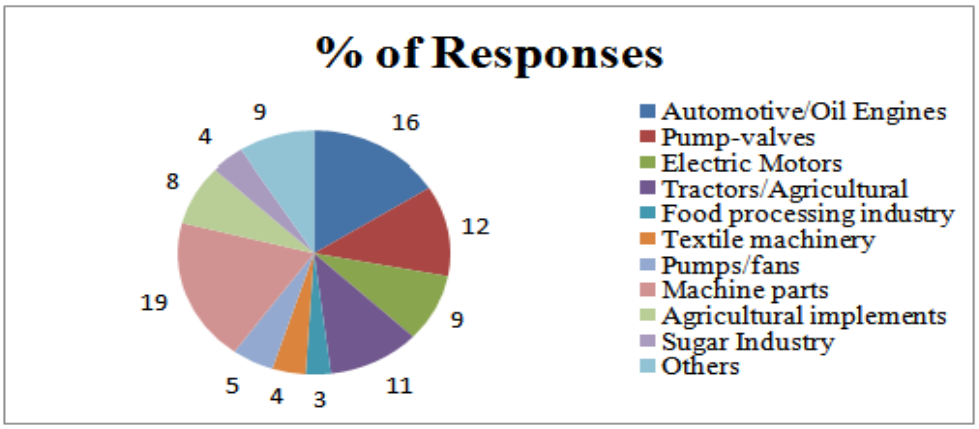

Fig. 3 End Use Market

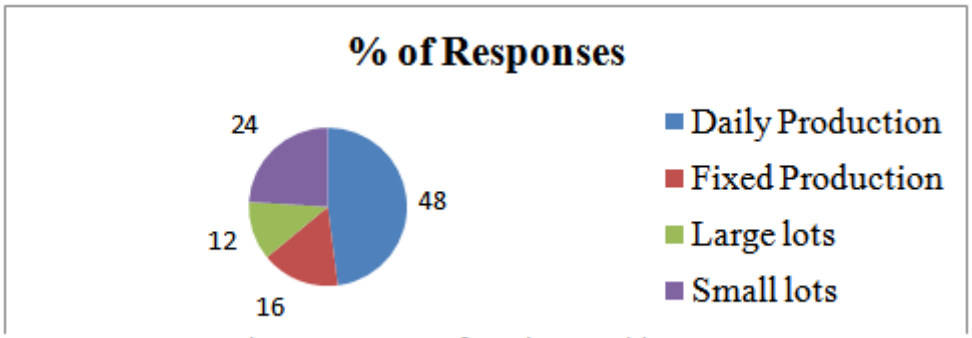

Fig. 4 Response of Product Architecture

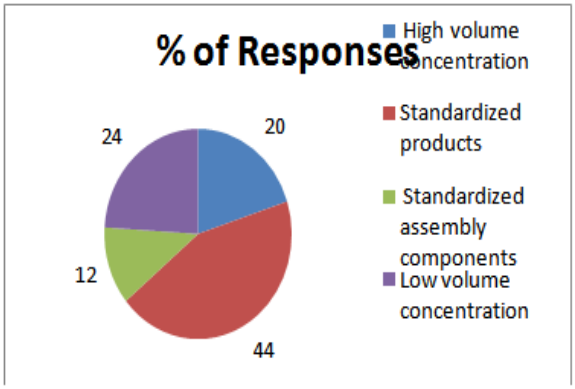

Fig. 5 Process Architecture

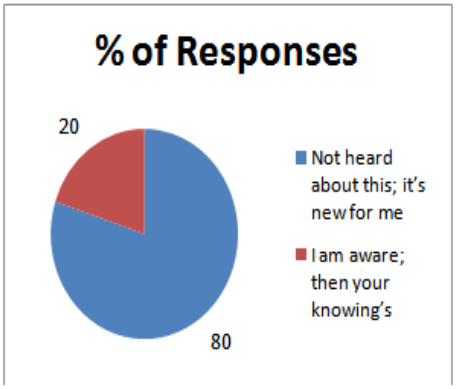

Fig. 6 Awareness of lean and Sustainability

4.1 Analysis and interpretation of Section C

In this section respondent asks to answer the what type of waste mainly occurs in their organization, which type of root cause corrective they have previously applied, what is the management feedback for application of the corrective system, role of management for the lean sustainable programme, and stand point for sustainable and environmental issues.

1 Combined Waste

The fig. 7 shows the percentage graphical representation of Type of combined waste. The graph shows that all the wastes occur in approx. same manner with higher percentage of 23 % in defects and lowest in 1 % in underutilization of creativity type of waste.

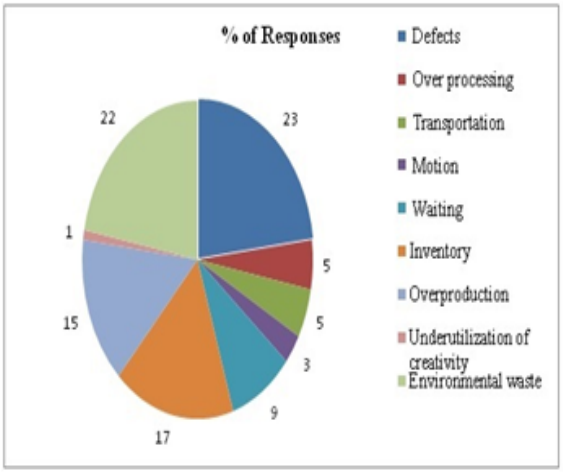

Fig. 7 Type of combined waste

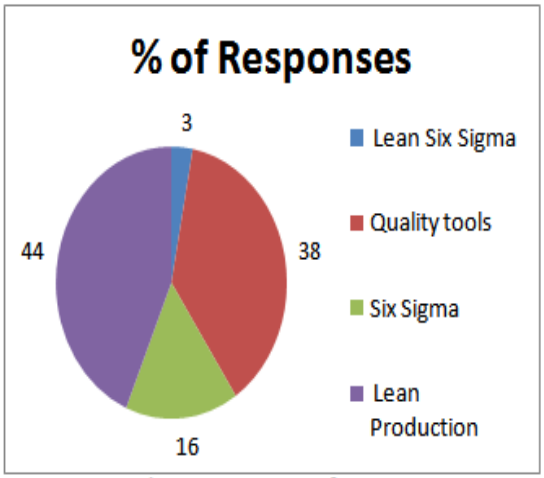

Fig. 8 Responses of Root cause

2 Root cause corrective system

The fig. 8 shows the percentage graphical representation of Root cause corrective system used. The graph shows that maximum 44 % organization uses Lean production for corrective system for removing root causes, so this is good for our research to implement the lean manufacturing tool in the organizations because people are familiar with the system of lean. Six sigma is lesser only 3 % organizations used for corrective system.

3 Management Feedback

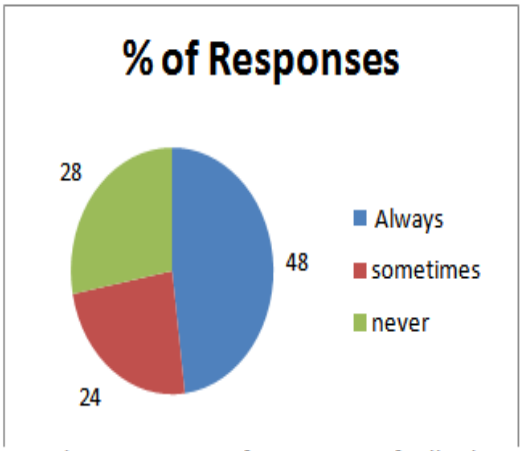

Fig. 9 Responses of Management feedback

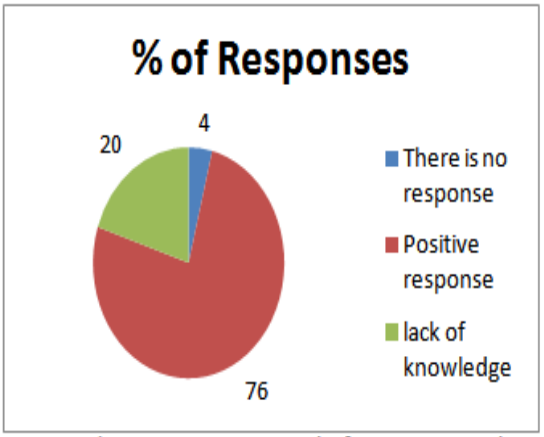

Fig. 10 Management role for programmed

The fig. 9 shows the percentage graphical representation of Management feedback. The graph shows that 24% times management gives feedback in category of "Sometimes", so this shows management is not aware that much for the corrective system applied in the organization and 28% under the category of "Never", so this shows that management is bit aware for their organization.

4 Management role for Programme

The fig. 10 shows the percentage graphical representation of Management role for programme. The graph shows that maximum 76% response for the category "Positive response", so this shows that management is willing to apply the lean sustainability programme in their organization and the lowest 4% response for the category "There is no response", so the few of organization didn't give response for the lean sustainability programme.

4.2 Analysis and interpretation of Section D

In this section respondent asks to answer the management commitment for lean implementation programme, cooperation of team members towards the programme, Factors identified for sustainability issues,

most Common problem in implementation of the programme, where is lean sustainable in the organization stands for, is lean and sustainable both applicable in system simultaneously, critical factors or barriers in implementation of the programme, benefits of implementation of the lean sustainable programme.

1 Management Commitment to programme

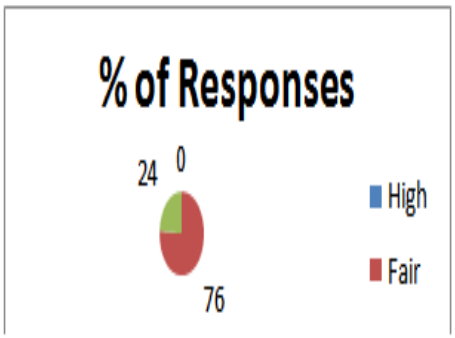

Fig. 11 Management commitments for programmed

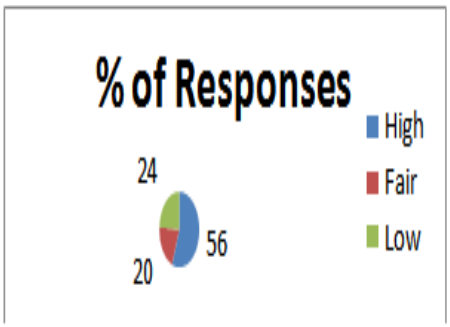

Fig. 12 Cooperation of team members

In fig. 11 the graph shows that maximum 76 % management of the organization commitment to the lean sustainable programme is fair and lowest 0 % is High commitment to the lean sustainable programme.

2 Cooperation of team members

In fig. 12 the graph shows that maximum 56 % workers are cooperative of the organization commitment to the lean sustainable programme is High and lowest 20 % is Fair commitment to the lean sustainable programme.

3 Critical factors in implementation

The graph shown in fig. 13 shows that the factors which are critical for the implementation are distributed among the entire circle, in which maximum 26 % the Seeing the tree but not forest which affects the most and silo thinking affects the lowest 3 %.

4 Benefits of implementation

The graph shown in fig. 14 shows that there are lots of benefits from the implementation of lean in the R M foundry organizations present in Hanumangarh area. Maximum benefit 26 % is attained from Sustainability indicators are easy to measure and 4 % from the others category which includes efficiency improvement for new product development, some aspects related to sustainability is also there.

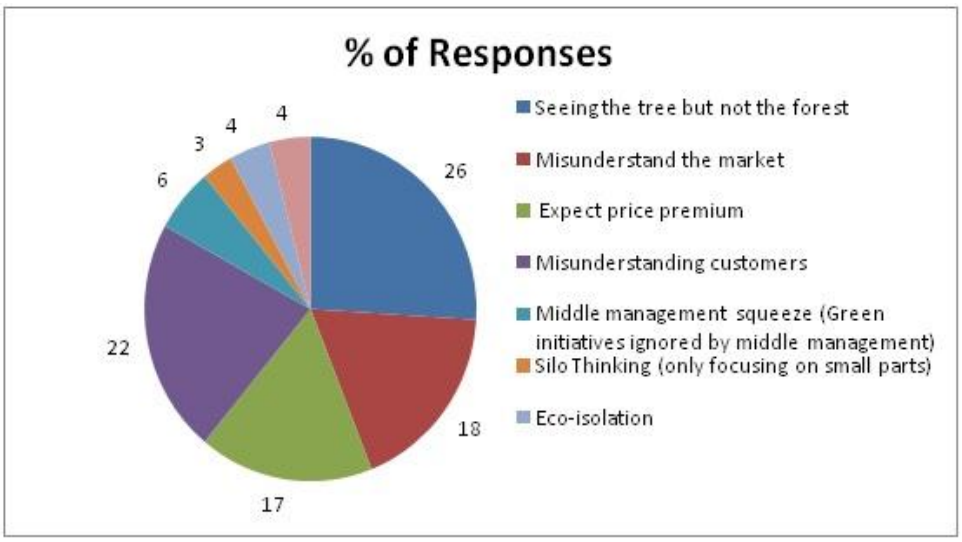

Fig. 13 Critical Factors in implementation

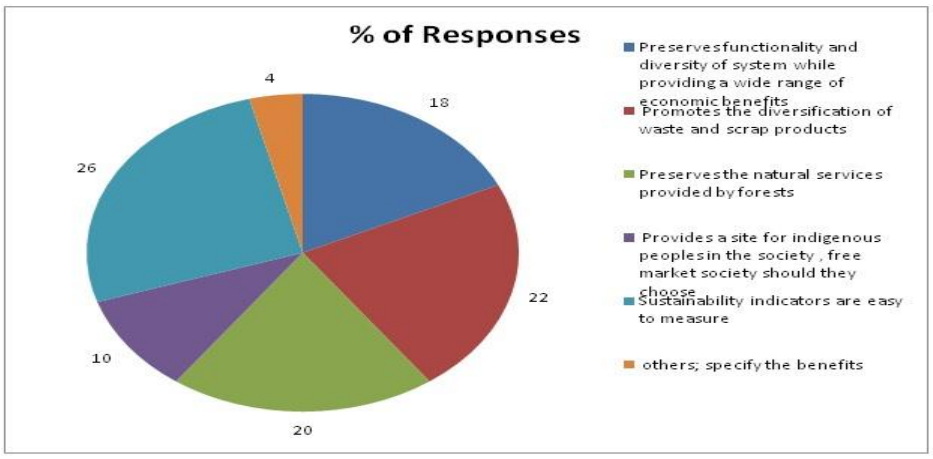

Fig. 14 Benefits of implementation

In summary, production improved after the implementation of the Lean System. This response was validated by the results produced after having established objectives that were possible to achieve. These objectives were established at the preparation phase of the implementation stage. Most of the organization agreed that after implementing lean in the organization the improvement taking places and a few organization are missing the worker's cooperation so they are not getting fully result for the value they have applied.

V. CONCLUSION AND FUTURE SCOPE

It is important to understand that Lean is a journey and not a destination. It has been shown that everyone in the organization must understand that Lean Manufacturing is here to stay. The rate of change at any organization depends on many factors. In the case of the Foundry, this may include changes to the market demand which may imply a change in the customer demand or mind-set; private sector change in movement of products. The work that has been completed in the pilot study must serve as a motivation for the complete implementation of Lean Manufacturing. It is essential that the critical support services like production planning and the Quality Control Laboratory become part of the main analysis of product stream; and not merely serve as a support service to the manufacturing operations.

From the study, following concepts known about the Lean:-

- When an organization is involved in Lean, shortened delivery times are possible along with other improvements.
- There is evidence of a variety of barriers preventing full implementation at the foundry. These barriers must be accurately identified appropriate action must be taken to overcome them.
- The results have shown that the Lean Manufacturing has improved productivity.
- So applying lean manufacturing concept in foundry gives good result in less time and also gives some new creative ideas.
- The feedback received from the respondents that the Lean Systems implementation was successful.
- Sustainability hardly provides any other incentives for lean than financial ones. Although an extraconstancy of purpose is not offered by sustainability, the emerging economic urgency may create a useful tide for lean.

The study shows that when Lean Manufacturing is applied in Foundry Industries, it decreases the delivery time of product. This was happened due to the reduction in the wastes involved in the manufacturing. When wastes are removed then it ultimately reduces the lead time and provides the sustainability in the manufacturing.

Many tools can be adapted for organization needs and there is a need to provide guidance on how to choose tools and increase the accessibility. Improve access to internal and external financial support / capital for organizations, and will include sustainability aspects in financing.

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