

Implementation Of 5S Methodology In The Small Scale Industry: A Case Study

R. S. Agrahari, P.A. Dangle, K.V.Chandratre

Abstract: 5S is a basic foundation of Lean Manufacturing systems. It is a tool for cleaning, sorting, organizing and providing the necessary groundwork for workpiece improvement. This paper dealt with the implementation of 5S methodology in the small scale industry. By following the 5S methodology, it shows significant improvements to safety, productivity, efficiency and housekeeping. The improvements before and after 5S implementation is shown by pictures in the paper. It also intends to build a stronger work ethic within the management and workers who would be expected to continue the good practices.

Keywords: 5S, productivity, Lean Manufacturing, Analytical Hierarchy Process (AHP).

1 INTRODUCTION

5 S is an approach to organize, order, clean, standardize and continuously improve a work area. 5S is not just about housekeeping, It is one of the efficiently working tools of Lean Manufacturing. The program gets its name from five activities beginning with the letter S, which were derived from five Japanese words. The words are Seiri, Seiton, Seiso, Seiketsu and Shitsuke, which when translated mean Sort, Set in Order, Shining, Standardize and Sustain, respectively. Sort helps to remove all unneeded items: only what is needed stays. Set establishes locations and quantities needed for efficient operation. Shine represent cleaning through inspection. Standardize implements visual displays and controls. Sustain helps to keep the organization effort in place through training and total employee involvement. The aim of this paper is to implement 5S methodology and measure the performance improvement in V.M. Auto Pvt. Ltd. A small scale industry situated at Satpur (M.I.D.C), Nasik. 5S is a lean manufacturing tool for cleaning, sorting, organizing and providing necessary ground work for work place improvement. 5S is already selected using Analytic Hierarchy Process (AHP), a multi criteria design making (MCDM) tool by considering different criteria for case company. AHP is a problem solving framework based on the innate human ability to make sound judgement about small problem. It is a quantitative technique use to facilitate decision that involves multiple competing criteria.

2 PROBLEM STATEMENT

The small scale industry occupy a prominent position of unique importance in economy of India. It has emerged as powerful tool in providing relatively larger employment next to agriculture. Global markets are continuously changing and demanding product of high quality and low cost. In India, the survival and the growth of small scale industry largely depends on its ability to innovate, improve operational efficiency and increase productivity. Many business have been trying to adopt new business initiative in order to stay alive in the new competitive market place. Lean manufacturing is one of these initiatives that focuses on the cost reduction by eliminating wastes(non value added activities). Research at Lean Enterprise Research Centre (LERC) U.K. indicates that for a typical manufacturing company the ratio for activity could be broken down as value added activity-5%, non value added activity (waste)-60% and necessary non value added activity-35%. This implies that upto 60% of the activity at a typical manufacturing company could potentially be eliminated. All Lean manufacturing tools are not possible to implement in small scale industry because of limited resources, i.e. finance, infrastructure, work force etc. The 5S, potential Lean manufacturing tool selected through AHP considering different criteria is to be applying for performance improvement of case company.

Definition of '5Ms':- A manufacturing quality problem solving model or tool that is based on using five factors of manufacturing namely Manpower, Machine, Medium, Mission and Management to gain desired outcomes.

Definition of 5S:- A philosophy based on five Japanese terms utilized for creating and sustaining a well organized workplace that is more efficient and productive in operation.

3 LITERATURE REVIEW

This section reviews the current literature on Len and 5S practices. It explores the concept of 5S and its implementation in a workplace. The basic foundation and its philosophy highlight the significance of 5S.

3.1 Lean Manufacturing

The roots of Lean manufacturing concepts are derived from the production system of the automobile manufacturing industry. The first cars of master craftsmen were built using a wide range of skills and abilities but with low efficiency and a high cost. Later Henry Ford documented these limitations

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and broke the assembly process down into 30 second tasks, which were performed almost a thousand times a day (Krafeik, 1988). Later the concept of teamwork create the Toyota Production System (TPS) by merging the skill of master craftsmen with the knowledge of Eiji Toyota and Taiichi Ohnos for the first time in 1990, Womack, Jones and Roos famous book wrote about the Lean Manufacturing concept. All service or production industries can implement Lean Manufacturing to reduce & eliminate waste in a manner that is simple, feasible, reliable, cost effective and synergistic with other programs. Lean Manufacturing defines waste as anything that adds cost to the product, without adding value that the customer would pay for (Pirraglia, Saloni & Van Dyk, 2009). Therefore lean practices help improve the product or information flow through the process, shorten the lead times, support continuous improvement and as a complete philosophy, help reduce defects of the products or information (Marchwinski, 2007). Cutting cost is not only the aspect that Lean manufacturing is concerned with (Pirraglia, et. al, 2009). It is also used to get big benefits using less human capital, space, monetary capital and time, which free resources to increase available capacity (Womack & Jones, 1991).

3.2 5S-The Beginning of Lean

5S is the one of the essential steps in motion and bring about a flourishing Lean culture (Cooper. Et. al 2007). It provides the ground work and the workplace as a way to modify how people approach their planned future state. Van Pattern (2006) and Samuels (2009) concur that 5S is often understood as a simple strategy to clean the shop floor but it can be potent application for developing a successful business for deploying a new standard of workplace practices. When everything has a place and there is a position for all things, a 5S program will serve for supporting a clear picture of the workplace

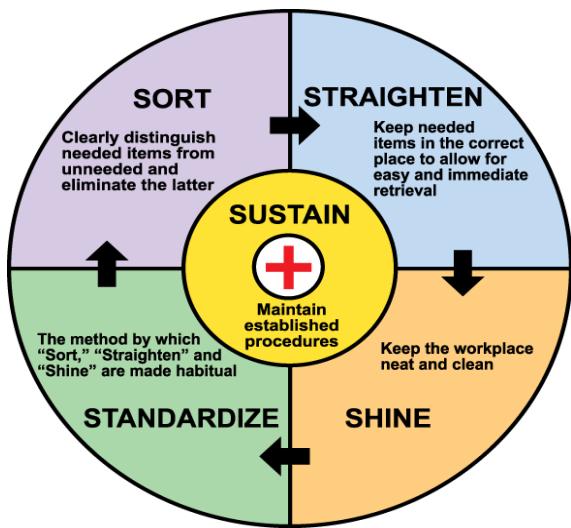


Fig. 1. The Schematic Diagram of 5S principles.

(Bullington,2003). Many organizations not only apply 5S as a first step of going Lean but also emphasizes on the removal of wait time and no value added activity. In a 5S workplace, tools kept on a shadow board are obvious at a distance and time spent looking for items is greatly reduced (Howell,2009).

4 5S THE PROCESS

Steps of the 5S process are as follows:

4.1 Sort (Seiri)

Sorting is the first step-removing all surplus items from the work center which are not needed for the immediate continual operations (Hough,2008). At this stage it is decided what is really needed and what is not. Any item or tool that is unaccounted out of place or unnecessary needs to be clearly documented. A red tag is a document made on red colored paper that is attached to potential junk items in a workplace. The items are stored temporarily until assignable action can be undertaken, it is usually the starting point of a 5S exercise. Items are red tagged with the best description of use or placement recorded on it. All red tagged articles are moved to a temporary holding area, and that area clearly is identified as the red tag or Seiri area. Equipment or anything else that is not of use, should be discarded as refuse to be thrown out (Howell, 2009). To implement the first step of 5S, a production team needs to know what material is used when the material in storage are to used where the required materials are, and what the users requirement are (Hirano 1993). This is an opportunity for every team to re-evaluate the tools at their disposal and make sure that they are using the best available tools for the process (Cooper et. al 2007).

4.2 Set in Order (Seiton)

The second step in a 5S launch is taking the stored items and putting them where they best support the function they provide. Workers should be motivated to place items at their point of use and improve the workplace's visual management (Van Pattern 2006). Before and after photos should be taken to document progress and explain activity benefits are of key importance at this stage (Samuels, 2009). One important advantage of Set in order is that everything needed for the job is clearly visible. Another objective of this step is to arrange the work in such a manner that missteps can be easily identified and corrected which is one of the main reason why the implementation of visual controls is encouraged during this step. Associates may apply these philosophies by referring to checklists, designing tool boards, parts container and improving workplace design. The practice of shadow boarding can be quickly identify when a piece of equipment is missing from a work station (Becker 2001). The main advantage of tool "shadowing" is that people instantly know which tool is missing and where it stored. Further more if one is missing its easy to guess what shop users are looking for and where it belongs.



Fig. 2. The shadow board displaying all the equipment and tools at its right place.

4.3 Shine (Seiso)

Once the unneeded is thrown away and sorting and set in order has taken place, it is now time for the sanitize phase (Howell, 2009). A cross functional team should agree on what the cleaning standards need to be (Samuels, 2009). This is sometimes referred to as shine or sweep stage where teams thoroughly remove clutter and fix equipment or building components (Hough 2008). The objective of this phase is to identify and eliminate the root cause of waste, dirt and damage as well as clean up the work station (Van Pattern, 2006). 5S projects that are almost entirely focused on cleaning and painting, prevent recording the valuable information that can be gained from assessing it (Van Pattern, 2006). This step needs to have the full involvement of employees to gather the data of what they feel needs to be cleaned and how often it should be cleaned (Samuels, 2009). Although it is imperative to create a cleaning schedule along with appointed duties for all personal working in designated areas, some employees may mistakenly believe that they are not being paid to clean. In that situation, Cooper. Et. al (2007) make the suggestion to list all applicable responsibilities in detail, including all areas to be cleaned and desired expectations where they are assigned. Another issue worth considering is that an unclean area is more susceptible to safety hazards that could potentially cause worker injury (Howell, 2009). This is of such importance that Cooper, Et al (2007) also recommend this particular event be followed as a daily regimen.

4.4 Standardize (Seiketsu)

After the organizing and cleaning of a production area, it is essential that the area is maintained (Cooper, et. al, 2007). This stage requires that the improvements of the previous three phases are maintained. That's why organization develop standardized procedures, rules and expectations for maintaining continuous activity in all of the areas shift by shift and crew. This is a means of creating consistent ways for implementing the tasks outlined above on daily basis (Cooper. Et. al.2007). The challenge is to visually maintain known agreed upon conditions rather than to write work instructions (Van Pattern, 2006). Teams can develop their own standards by using the 5M's borrowed from Kaoru Ishikawa's Fishbone

diagram. In it, he lists Manpower, Methods, Materials, Machines and Measurements as the 5 components of the standardizing step (Ishikawa, 1986). An organization achieves conformity when employees value working to one common metric, rather than working however they feel like working or how they think a job should be done (Van Pattern, 2006).

4.5 Sustain (Shitsuke)

The benefits of the above four phases of 5S are powerful, visual and easily measured. However without self discipline, elements for sustainability the success of 5S program is brief and everything will atrophy or revert to the previous messy state (Maggie, 2006). In daily life, when we diet to lose weight, we still need discipline to help us maintain our objective. Therefore discipline and motivation go hand and hand to reach your goals (Santos Wysk& Torres, 2006). Several Studies identify the fifth phase as the most difficult phase to perform of this program (Bullington, 2003 ; Cooper et. al, 2007 ; Womack & Jones 1991). To continue the gains from implementing the 5S system, efforts should be taken to instill the importance of maintaining employee dedication for a neat, orderly and safe workplace and reinforcing good work habits (Maggie, 2006). Every employee needs to understand the importance of safety, order and cleanliness and be willing to take the necessary steps that guarantee the prescribed standards are accommodated (Cooper et. al 2007) when every square foot of a production floor is assigned to an associate then clutter will not build up (Samuels, 2009)

5 IMPLEMENTATION OF 5S

5.1 Guidelines for practicing SORT

The first S focuses on eliminating unnecessary items in the workplace. It is the series of steps which keep only

- what is needed
- the amount needed and
- when it is needed

To implement the first S the Red-Tag process is commonly employed. The Red-Tag strategy helps to identify unwanted items and determine their usefulness. There are six steps involved in creating a successful Red-Tagging process.

Step 1: Launch the Red-Tag Project

This is usually done by the Steering Committee by creating holding areas and planning for the disposal of unwanted items using the Red-Tag form.

Step 2: Identify the Red-Tag Targets

Specify the type of items and the physical work areas to be evaluated.

Step 3: Set Red-Tag Criteria

Three questions need to be asked to determine if an item is necessary.

- Is it useful ?
- How often is it needed ?
- How much is needed ?

Step 4: Attach the Tag.

The Red-Tagging event must be quick and decisive. The target scope must be completed before the Lunch.

Step 5: Evaluate Red-Tagged Items. Decide what to throw and the actions required

Step 6: Document the Results of Red-Tagging. Results must be logged for accounting purposes so that the organization can measure the improvements and savings realized through the process.

UNNECESSARY ITEMS

- Throw away immediately
- Items having no value and easy to dispose

REQUIRED ACTION

- Look for buyer who offers the best price
- Items having some sale value
- Work out the least costly and safest way for disposal
- Items having no value and their disposal is costly

When Red-Tagging is completed and action taken as in Figure, workflow is reduced, communication between workers is improved and productivity is enhanced.

Department:	Section:								
Area/Location:	Tagged By [name]:								
Classification: (Please tick)	<table border="1"> <tr><td>1. Office equipment & furniture</td><td>5. Used oil/Schedule waste</td></tr> <tr><td>2. Raw Material & Consumables</td><td>6. E & I parts</td></tr> <tr><td>3. Finish Goods</td><td>7. Mechanical Parts</td></tr> <tr><td>4. Scraps</td><td>8. Others:</td></tr> </table>	1. Office equipment & furniture	5. Used oil/Schedule waste	2. Raw Material & Consumables	6. E & I parts	3. Finish Goods	7. Mechanical Parts	4. Scraps	8. Others:
1. Office equipment & furniture	5. Used oil/Schedule waste								
2. Raw Material & Consumables	6. E & I parts								
3. Finish Goods	7. Mechanical Parts								
4. Scraps	8. Others:								
Item Description									
Identification Number:	Quantity: (No of pos/kg)	Estimated value RM:							
Reason (please tick)		Actions (please tick)							
1. Not required	2. Defective	3. Expired	4. Excess/Surplus						
5. Scrap	6. Others	7. Move to separate storage shelf/store	8. Repair						
Remarks		Action Date							
Proposed by:	Verified by:								
Name: _____ (Date: _____)	Co-ordinator's name: _____ (Date: _____)								
Approved by (Department Head)	Additional Comments by Department Head:								
Name: _____ (Date: _____)									

Fig. 3. Example of Red Tag

The key word in this description is the elimination of unnecessary items in the workplace. Sorting is an excellent technique to transform a cluttered workplace layout into an effective area to improve efficiency and safety.

Potential Impacts:

- Necessary items are identified and positioned in the right workplace and location.
- Unwanted items are eliminated.
- Searching time is reduced.
- Working environment is improved.
- Space utilization is maximized.

5.2 Guidelines for practicing Set in Order

The second S reflects a very popular saying: "A place for everything in its place". It emphasises safety, efficiency and

effective storage and consequently improves the appearance of the workplace. Once the first S has been successfully implemented, what is left should be arranged so that there is ease of use and storage as illustrated in Figure 4.



Fig. 4. Second S Action Plan

The process shown in Figure 4, eliminates waste in production or in clerical activities and ensures all materials, tools and equipment have designated locations which are easy to find. The second S includes activities such as:

- Mark reference materials with an oblique line to detect disorder from a distance.
- Put names and numbers on all jigs and tools.
- Store tools beside the machine with which they will be used according to sequence of work operations.
- Organize files and store using color code to make it easy to identify materials at a glance.
- Store similar items together.
- Store different items in separate rows.
- Do not stack items together, use rack or shelf.
- Use small bins to organize small items
- Use color for quick identification of items.
- Label clearly each item and its storage area (Visual Control)
- Use see-through cover for better visibility.
- Use specially designed carts to organize tools, jigs and measuring devices that are needed for each particular machine.
- Create tool boards.

The key word in this description is anyone. Labeling is specifically for other people who need what is in area, when the area owner is away. The benefit is searching time reduced. When orderliness is established, there is no human energy waste or excess inventory.

Potential Impacts:

- Items easily returned to its designated location after use.
- Required items easily located, stored and retrieved.
- First-In First-Out (FIFO) is practiced.
- Retrieval time is reduced.
- Right Item, Right Place, Right Quantity and Right Method (4R) are in place.

5.3 Guidelines for practicing Shine

The third S stresses on cleanliness because it ensures a more comfortable and safer workplace, as well as better visibility, which reduces retrieval time and ensures higher quality work, product or service. The third S is to thoroughly clean the work

area. Daily follow-up cleaning is absolutely necessary to maintain a clutter-free workplace and a desirable environment. SHINE speaks for itself. Everyone enjoys working in a clean environment which raises morale and increases productivity. To successfully implement the third S as a daily value-adding activity, the following steps must be practiced.

Step 1: Delegate Cleaning Assignments. Cleanliness is the responsibility of EVERY employee and the workplace must be divided into distinct cleanliness areas, which can be based on:

- 5S Zones:

Show all the cleanliness areas and the names of the people responsible for them.

- 5S Schedules:

Show in greater detail the different areas and the names of those responsible for them, including daily rosters.

Step 2: Determine What is to be Cleaned. Develop targets and categories them for ease of use.

Step 3: Determine the Methods to be Used. Decide on the tools and materials required and what is to be cleaned in each area. Cleanliness must be practiced daily and must take only a short time to execute. Standards must be adopted to ensure people do the cleaning efficiently.

Step 4: Prepare the Cleaning Tools and Materials. Set up cleaning tools and the required materials in such a manner so that they are easily retrieved for use.

Step 5: Implement Cleanliness All equipment malfunction or defects must be fixed or reconditioned. The key word in this practice is keeping the workplace and everything in it clean and in good functional condition. This is achieved through the combination of the cleaning function and defect detection.

Potential Impacts:

- Higher quality work and products.
- More comfortable and safer work environment
- Greater visibility and reduced retrieval time
- Lower maintenance cost
- Creates positive impression on visitors and during customer inspections.

5.4 Guidelines for practicing Standardize

The continued employment of the 3S will ensure a high standard of workplace organization. Once the 3S are in place, the next step is to concentrate on standardizing best practices. The plant must include the creation of procedures and simple daily checklists which are to be visibly displayed at every workplace.

- Job responsibilities that include:
- Who is responsible? (ownership)
- What actions must be taken to maintain the desired condition?
- When must those actions be taken?
- Where must they apply?
- What procedures will be followed to ensure

compliance?

- Cleaning procedures
- Maintenance schedules

The checklists must serve as visual signpost to ensure that the daily 3S requirements are carried out habitually as best practices in the work area. Examples of checklists are: The key word is to consolidate the 3S establishing standard procedures. This activity is carried out to determine the best work practices and find ways of ensuring that everyone carries out their individual activity in their workplace.

Potential Impacts:

- Better workplace standards.
- Better Visual Control Systems.
- Establishment of Rules and Standard Operation Procedure (SOP).
- Information sharing on required standards.
- Improvement in operation and workflow

5.5 Guidelines for practicing Sustain

The fifth S is to make it a habit of maintaining the momentum of the previous four S to ensure sustainability of the system and to make further improvement by encouraging effective use

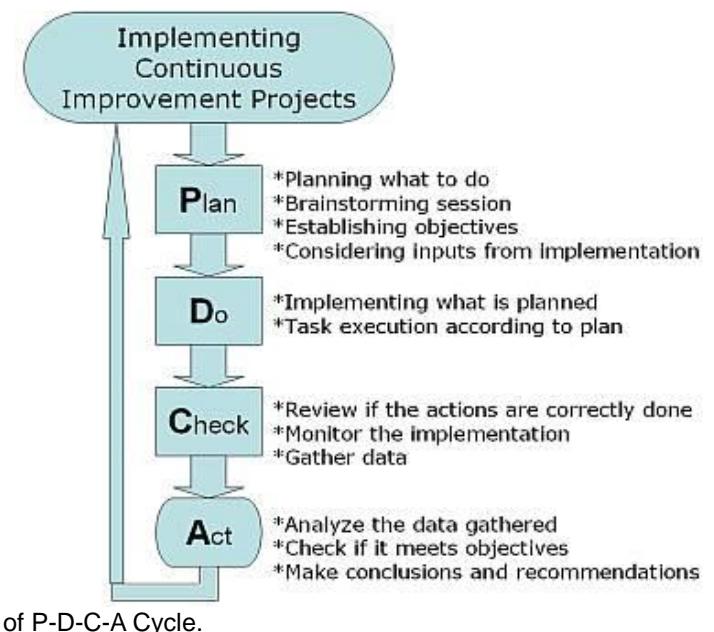


Fig. 5. PDCA Cycle

- Build awareness of the importance of 5S through retraining.
- Reward and recognize efforts of staff.
- Use techniques / approaches / strategies to sustain activities.
- Review :
- 5S Slogans and Posters
- 5S Newsletters to share the progress of 5S activities.
- 5S Achievements – standards and performance indicators

The last S stands for SUSTAIN which requires self-discipline without which it is impossible to maintain consistent standards of quality, safety and cleanliness.

The key word is this description is shared values. Shared values are achieved through coaching and team participation, not shouting orders and imposing penalties. The implementation of 5S involves coaching to get the workers to do the simple things right. Buying in to these basic values is the essential starting point to develop a World Class organization.

Potential Impacts :

- Compliance to workplace rules.
- Team spirit and discipline are developed.
- The 'Kaizen' mentality is inculcated in the employees.
- Adoption of best practices.
- Enhance operation effectiveness in a better working environment.

5 CASE STUDY

Well organized, clean, high effective and high quality workplace is the creation of 5S methodology. The study was carried out in the manufacturing company V.M. Auto Pvt. Ltd. During the study it was executed that selection of process parameters/procedure in chosen production process, on each workplace. The 5S methodology was introduced to workers and control questions have been asked. Each rule has been implemented and in consequence the great changes have appeared as reflected in figures.

5.1 5S Approach in Industry

The objective of our research was to increase the storing place with 30%, create and preserve standards and service procedures specific to the workshop, reduce unproductive time with 10%, redefine access, working and storage spaces, readjust the location. Changes that take place after 5S Implementation:

1S:

During the activity Red labels have been applied to all marks which were not necessary within the workshop.

- All useless things have been sorted and eliminated.
- Rubbish about approximately 300kg was thrown away.
- The reason for scanning accumulation was found out.
- The activity related rules have been stated and are to be implemented.



Fig. 6. Red Tag Zones.



Fig. 7. Before & After pictures of 1S SEIRI (Sort)

2S:

- The inappropriate objects have been taken inventory of
- In the workshop, the location of all necessary objects have been defined and marked.
- Colors have been used to mark the different areas.
- The arranging way has been set according to destination and degree of usage.



Fig. 8. Before & After photographs of SEITON

3S:

- Washing of floors was done.
- All floors have been cleaned.
- All storing shelves have been cleaned.

- All machines and tools have been washed and cleaned.
- Existing disturbances/non conformities have been detected.
- All boards have been cleaned as well as all the windows.
- The supply wiring has been redone.



Fig. 9. Photographs of 3S- SEISO(Shine).

4S:

The daily checklists were carried out.

- The specific procedure was followed.
- All obligatory rules in the company are obeyed.
- Rules and regulations of the company were followed.
- Establishment of Rules and Standard Operation Procedure (SOP)
- Improvement in operation and workflow.



Fig. 10. Marking and Standardization of the Templates with different color codes. (each color code specifies a particular company/product which helps in minimizing the problem of dispatching the different product to other company).

5S:

- It gives a scope for Workers participation in the work area design and maintenance.
- Workers absenteeism has been lowered down.
- Team spirit and discipline were developed.
- 5S slogans and posters were introduced.
- Enhancement of operation effectiveness in a better working environment was created

6 CONCLUSION

The advantages from implementing the 5S rules:

1S:

- Process development by cost reduction
- Stock confinement
- Better usage of workplace
- Prevention of losing tools

2S:

- Process growth
- Increasing Efficiency
- Shortening of time required for searching necessary things

3S:

- Improvised working conditions for workers.
- The number of customers has been increased after maintaining a clean and neat layout.
- Machine maintenance cost has been reduced.

4S:

- The standards of the company came to next level.
- Improvement in safety has supported in reducing the injuries of workers.
- Slips and falls of the material have been reduced.
- Travel time of materials is reduced which led to reduction of work hazards.

5S:

- It gives a scope for Workers participation in the work area design and maintenance.
- Workers absenteeism has been lowered down.
- Increasing of the awareness and morale.
- Decreasing of mistakes quantity resulting from the inattention.
- Proceedings according to decisions.
- Improvement of the internal communication processes.
- Improvement of the inter human relations.

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7 REFERENCES

- [1] Chauhan et al., "Measuring the status of Lean manufacturing using AHP" International journal of Emerging technology vol.1 no.2, pp.115-120. 2010.
- [2] Miller et al., "A case study of Lean, sustainable Manufacturing" journal of Industrial Engineering and Management, vol.3 no.1, pp.11-32. 2010.
- [3] Girish Sethi and Prosanto Pal, "Energy Efficiency in Small Scale Industries – An Indian Perspective" Tata Energy research Institute.
- [4] Chakraborty et al. "Internal obstacles to quality for small scale enterprises", International Journal of Exclusive management research, vol. 1, no. 1, pp. 1-9, 2011.
- [5] Upadhye et al. "Lean manufacturing system for medium size manufacturing enterprise: An Indian case" International journal of management science and engineering management. Vol.5, no. 5 pp. 362-375, 2010.
- [6] Hudli and Imandar, "Areas of Lean manufacturing for productivity improvement in a manufacturing unity", world academy of science, engineering and technology vol. 69, 2010
- [7] Lukas et al. "Lean implementation in a low volume manufacturing environment: A case study" Proceedings Industrial Engineering Research Conference (2010)
- [8] Kumar and Kumar. "Steps for Implementation of 5S", International Journal of management. IT and Engineering. vol. 2, no.6, pp. 402-416, 2012.
- [9] Gheorghe Dulhai. "The 5S strategy for continuous improvement of the manufacturing process in auto car exhausts", Management and marketing vol. 3, no. 4, pp. 115-120, 2008.
- [10] Khedkar at el. "Study of implementing 5S techniques in Plastic Moulding" International Journal of modern engineering research. vol. 2, no 5, pp. 3653-3656, 2012.
- [11] Prashant Koli." General Implementation and Calculation of 5S Activity in any Organization" International journal of Science and Research vol.1 no.3pp.229-232,2012.
- [12] Ansari, A. and Modarress, B., 1997. World-class strategies for safety: a Boeing approach. International Journal of Operations & Production Management, 17 (4), 389–398.
- [13] Ahmed, S., Hassan, M.H., and Taha, Z., 2005. TPM can go beyond maintenance: excerpt from a case implementation. Journal of Quality in Maintenance, 11 (1), 19–42.
- [14] Ahuja, I.P.S. and Khamba, J.S., 2008. Total productive maintenance: literature review and directions. International Journal of Quality & Reliability Management, 25 (7), 709–756.
- [15] Brown, K.A., 1996. Workplace safety: a call for research. Journal of Operations Management, 14 (2), 157–171.

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