The Review on Various Strategies Adopted for Implementing and Sustaining 5S in a Manufacturing Industries

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Abstract

In recent years, lean implementation has gained importance especially in India where wastes are classified into 7 types described as TIMWOOD in short form .5S is the initial step in implementation of lean principle where the workplace is made well organized and tidy. 5S consist of five Japanese words namely seiri (sort), Seiton (set-in-order), Seiso (shine), Seiketsu (standardize) and Shitsuke (sustain). 5S assist an organization in identifying waste, eliminating waste, reduction in equipment searching time, improve working condition, improving workers health and increasing productivity. Also, 5S is an effective tool in improving performance of an organization irrespective of type of ownership of the company whether be it small or large scale, service or manufacturing sector, private or governmental organization. The main focus of this review paper is to describe few strategies to implement 5S, Audit 5S and analyze effect of 5S on performance of workplace. The study has referred to many case studies and described some of the best methods through which a manufacturing industry can implement and sustain 5S methodology based on its mission and vision. The discussion on various methods is in brief in form of example for further in-depth information there is need to search for cited references.

Keywords
Productivity, Barriers, Efficiency, cyber security

1. Introduction
Nowadays, in technologically advancing world it is pivotal for a company to be pioneer in its products and competitive in order to survive in business. Generally, two major challenges are faced by top management. Firstly, lack of knowledge about the methods required to improve performance of company. Secondly, managers need to take correct decisions to achieve company's objectives and make sure not to lose any opportunities.

5S was first introduced to the industry by Takashi Osada back in 1970(Abdulmalek et al. 2006). Later Toyota engineers, sakichi Toyoda and Kiichiro took the initiative for implementing this technique commercially.5S helps to establish, maintain quality management in organization**.** Furthermore, some inherent benefits of 5S methodology are employee's high motivation, clean and tidy workplace, easy detection of defects on regular maintenance of machines etc.
There are lot of review papers available on 5S benefits but a quite few on reviewing tools, techniques and methods necessary for a company to implement and audit 5S. Here the paper concentrates on describing few methods to implement 5S in manufacturing company, Audit 5S and Tools to identify interrelationship between barriers and 5S failure in an organization.

2. Literature Review
As stated by (Michalska and Szewieczek 2007), The 5S methodology is influenced by few factors like Top management commitment , employees attitude , mission and vision of company etc. As described by (Ghodrati and Zulkifli 2012). It requires continuous monitoring of the process which can be ensured by preparing checklist and other 5S auditing tool.5S is an effective tool for improving organizational performance. The result of the above-mentioned study was supported by taking measurement before and after 5S implementation in which software like Statistical software for the social sciences (SPSS) and excel was used. Moreover, Research conducted by (Ghodrati and Zulkifli 2013) Showed significant improvement in housekeeping, productivity, safety and efficiency through 5S implementation. Apart from that (Rojasra

and Qureshi 2013). Conducted 5S implementation in Krishna plastic industry reported improvement in production efficiency from 67 % to 88.88 % in a single week.

(Salunkhe et al. 2015) showed through proper arrangement of items searching time got reduced by 50 % .As observed by (Ho et al. 2010), 5S still remains the fundamental to the organizations for having zero faults and zero accidents. Through, orderliness and cleanliness, quality can be improved. Furthermore, (Hirano 1995) stated that 5S methodology can help to better understand requirements of customers and helps to establish good relationship with them. Moreover, A study conducted by (Imai 1997), on Vedanta Aluminium co. Ltd revealed reduction of 50% time in maintenance and repair of 5-ton capacity crane as 5S technique was used to keep all essential tools and spare parts. Further, (Agrahari et al. 2015), demonstrated improvement in production process through 5S implementation leading to cost reduction, prevention of tool loss, better utilization of workplace, stock confinement etc. Beside that there was reduction in machine maintenance cost, improvement in safety leading to lower workers injuries and reduction in the travel time.

Finally, (rai 2016). Emphasised more on educating and creating awareness on 5S and its benefits to low level and middle level managers. There is awareness regarding 5S in few firms, involved in TQM implementation and top managers from SMES.whereas, another result came out suggested that employees are not 100 % responsible for 5S methodology implementation due to lack of awareness and training.

Figure 1. Steps of 5S methodology implementations

The Figure 1. depicts the sequence in which each 'S' is implemented. However, it is necessary to consider 5S as a continuous cycle where there is always scope for improvement in each step of 5S.

3. Research Methodologies

Current work discusses on tools and practices used to establish and sustain 5S practice in a manufacturing organization. The study has considered examples of many companies applying Statistical software's, specially designed survey questionnaire, Checklist, Hypothesis test, Regression test to implement and audit 5S methodology. The work aims to help manufacturing organization to know how to implement 5S methodology in order to increase productivity, efficiency and reduce cost in manufacturing industry.

4. Description on 5S and approach for implementing 5S

4.1 Seiri (Sort)

It involves categorizing every item into necessary item or unnecessary item. Red tagging is done on unnecessary items (Agrahari et al. 2015). Red Tag area is the area set aside for storing these Red tagged items. Red tag items consist of what is the item? How much quantity of that item? Why it is removed? Department form which the item belongs? Red tagging is done by asking following questions.

If this item required? and if required, is it required in that quantity and is it used that frequently?

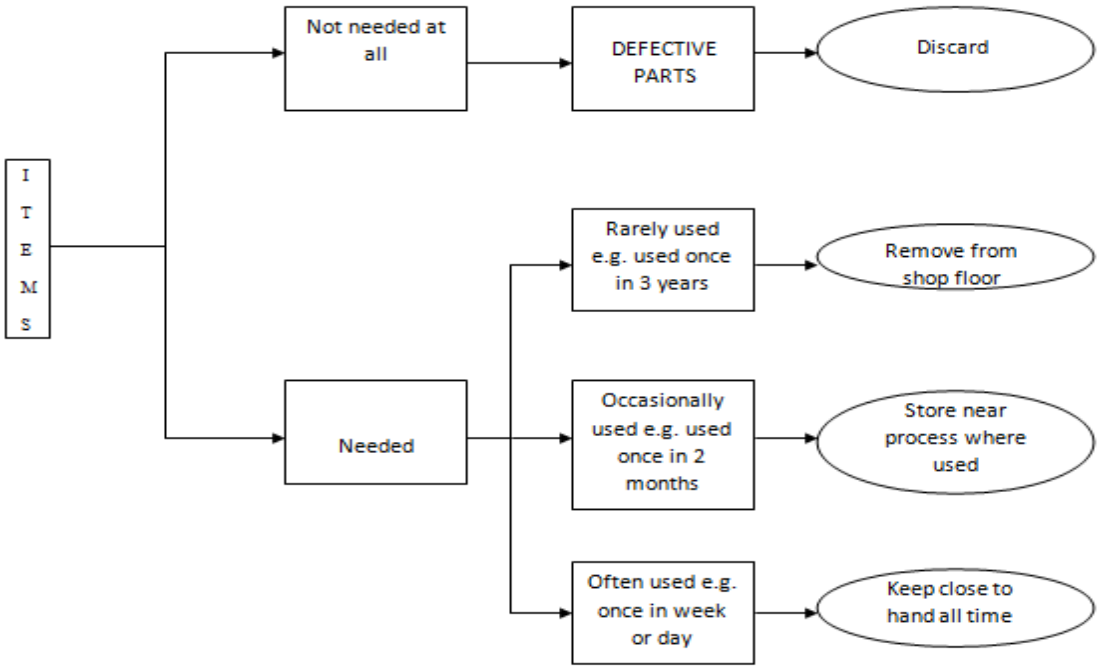

Figure 2. flowchart used for red-tagging items

In case the answer to any of the above questions is known than that item should be red tagged. Moreover, Figure 2. shows all decisions involved in assigning a red tag to a component in a typical manufacturing company.

4.2 Seiton (Set-in-order)

Seiton means to arrange necessary things based on frequency of use, size etc. and label them appropriately so that they are easy to locate and use. The implementation of this step is done in two phases.

Phase -I deciding the appropriate location
Depending on frequency of use tools and equipment's should be arranged, Store items in sequence if they are used in sequence or store items together if used together, Allocate more storage space than require to make it easy for operator to put back tools on their dedicated place, Prevent zig-zagging motion and sudden change in the direction of motion as it not ergonomic, Provide appropriate worktable height, so that technician can work in a good posture and there is no fatigue associated due to bad posture, Feet should be used to press switch for turning on/off machines.

Phase -II Identifying the location
Signboard strategy: Used to indicate location and number of items**,**
Painting strategy: To separate workstations from gangway
Color coding strategy: To give information on which item to be used when.

4.3 Seiso (cleanliness)

Seiso means to keep workplace neat and clean with an aim for easy inspection of machine equipment's, tools etc. Through cleaning, one can easily and quickly identify the possible defects and faults in the equipment. shine includes adequate lighting conditions especially in quality department where visual inspection and measurement activity is carried out.

Seiso can be executed in the following way**.**
Determine the shine target like storage space, workstations, gangway etc., Shining should be well defined in such a manner that it should not take more than 5 minutes if regularly implemented, Limits unto which things need to be clean

should be well-defined a priorly, Allocates shine assignment among employees. The work can be divided in terms of area of cleaning or time of cleaning.

Following are the questions which need to be answered during this step
Are there any oil strain, dust, dirt lying on the shopfloor? Is the machine neat and clean? Are the pipe lines protected from corrosion and is the pipe outlet clogged by dirt? Are the light sources like windows clean?

4.4 Seiketsu (standardize)

It includes creation of standard operating procedures and set of well-defined instructions in order to ensure that condition of an organization does not return back as it was before 5S implementation (Agrahari 2015). Moreover, drawing out shapes of tools makes it easy to return them on their dedicated place.

There are two phases involved in implementing this 4^{th} S
Phase -1 making it Habit
Decide individuals responsible for seiri, set-in-order and standardize, include above 3S activities into regular work duties, Audit the 3S conditions over regular time interval, Categorize used things into 3 categories

a) in close access b) accessible c) in the range of hand.

Phase -2 Prevention
Ensure tools and fixture do not get accumulate, Design rack in such a manner which makes it difficult to arrange tools in wrong place.

4.5 Shitsuke (Sustain)

Here the primary focus is on making 5S as an organizational habit. This can be implemented with a goal to improve productivity, increase quality and decrease in production cost by waste elimination (Yogesh and Kulkarni 2016).

Following are the actions to be taken for sustain implementation
Responsibility – Add 5S as a responsibility in the job profile of employees with a specific department allotted.
Awareness –Through meeting, campaigns information on 5S should be passed down to each and every employee.
Time – A certain portion of day should be allocated for 5S activities.
Support – Top management support is pivotal to sustain 5S.
Rewards –To give rewards on effective implementations and sustenance of 5S.
In Addition to 5S, safety and security are additional 2S leading to a total of 7S.

4.6 Safety

Safety is on the 6^{th}S, focusing on potential hazardous to workers health and identifying preventive controls to keep workers safe. Safety plays a significant role on improving work atmosphere and creating a stress-free environment where workers feel safe and secure. (Safety culture 2022). Moreover, quality and productivity enhance as it is easy to recognize potential future hazards and install safety control. Here, there is a need to include safety as separate step to get more attention on it especially for manufacturing industries involving casting process, welding process, gas cutting etc. where there are more chances of accidents.(Sukdeo 2017).

4.7 securities

Security not only involves protecting company from physical threats but also from cyber threats. (Hulme 2022). With ever increasing use of Enterprise Resource planning (ERP) software to upload client information, designs of manufacturing firms. It is essential to protect their intellectual property from cybercrime.(Sukdeo et al. 2020).

Following are the ways an organization can get secure from cyber crime
Awareness among employees on cybercrime, Email Domain security, Identify access management (IAM), Incident response tool, Regular data back for offline use.

5. 5S Implementation strategies

5S implementation leads to quality enhancement and reduction in wastes, because of which a company successfully practicing 5S, will be able to certify itself for ISO 9001 and ISO 14000 (O'hEocha 2000). However, before implementing 5S in any organization one need to identify potential barriers and benefits of it. (Jain et al. 2014). moreover, the source

of barrier and benefits needs to be classified into three levels namely top management, middle management and shop floor worker. (Attri et al. 2020). The table 1. Shown below can be modified and applied by any manufacturing company for 5S implementation. Here organization should list all the barriers and benefits it will obtain on 5s implementation so that the barriers can be addressed accordingly.

Table 1. Example of identifying barriers and benefits of 5S implementation in a Hinge manufacturing company

	Top management	Middle management	Shop floor worker
Barriers			
Lack of planning	+	+	+
Communications	+	+	+
Management structure	+		
Benefits			
Fast retrieval of Items		+	+
Saves time	+	+	+

+ = Indicate barrier or benefit identified as important

5S is a practice which needs to be sustained through regular 5S audit in order to identify potential improvement areas (Rahman et al. 2010). Furthermore, 5S audit can be external or internal and it can help to monitor 5S deployment and ensure its proper implementation. For manufacturing firm carrying out its 5S audit can decide its own criteria based on business strategy, mission and vision of an organization. In addition, one of the main challenges in 5S audit is designing suitable and reliable questionnaires to collect accurate information. Likert scale is use most often (Ghodrati and Zulkifli 2013). It ranks 5S implementation in terms of good, very good and excellent. This ranking is converted into suitable percentage.

5.1 Likert scale for 5S audit

The Figure 3. indicates the steps in which Likert scale is used to quantify the level of 5S implementation of each department. Thus, identifying scope of improvement based on obtained result.

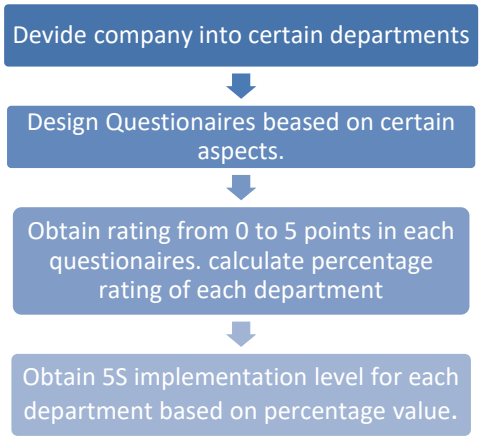

Figure 3. shows the steps to perform 5S audit

Here Table 2. illustrates standard marking scheme used by major manufacturing companies to quantify 5S status of each department.

Table 2. gives Implementation level in each department before and after improvement in 5S

Scale of marking (%)	Implementation level

90-100	Excellent
80-89	Very good
65-79	Good
51-64	Moderate
0-50	weak

After 5S implementation its effectiveness can be verified by collecting primary data (Ghodhrati 2012).showed that Primary data can be collected through questionnaires designed by considering established rules .furthermore, SPSS software should be used for pilot study to check validity of data obtained from survey .In addition , Cronbach's Alpha approach (Taber 2017) (table 3) can be used for reliability analysis. Reliability of a measure shows stability and consistency with which software measures the concept. Data is reliable if Cronbach approach scores above threshold value. Finally, The Likert scale should be used to quantify each defined parameters, where 1= Extremely disagree and 5= extremely agree. Finally a software can be made to answer survey questionnaire in order to prevent manual labor(Khamis et al. 2009).

Table 3. Shows sample Cronbach's Alpha analysis in a manufacturing unit

Variables	**Cronbach's Alpha**
Role of management	0.77
Training	0.15
Employee's awareness	0.668
Productivity of workers	0.87

5.2 Tools to identify barriers for 5S sustainability and Implementation

Method-1 The main idea of this concept is to identify factors leading to sustenance failure of 5S and based on which hypothesis test can be proposed. The below table contains 3 hypothesis and each hypothesis is classified into 5 factors. (Davis et al. 1995). Moreover, for each factor, 2 questions were asked and based on Linkert scale, respondents were asked to give questions. t-test, p- test etc. can be used for obtaining result from hypothesis for obtaining a very practical example which can be implemented in any manufacturing unit with little modifications. Table 4. Indicates some of the common barriers leading to failure of 5S and how null and alternative hypothesis is used to conclude which one is responsible for 5S failure.

Table 4. showing sample hypothesis test in any organization

Hypothesis number	**Null hypothesis= H_0 Alternative hypothesis= H_1**	**Factors for each hypothesis**	**Result (indicating which hypothesis to accept)**
Hypothesis -1	H_0: less commitment from top management not causing 5S failure H_1: less commitment from top management causing 5S failure	➢ Budget for 5S ➢ 5S audit ➢ Safety ➢ 5S infrastructure ➢ Training	
Hypothesis -2	$H_{0:\ less}$ effort from 5S team member not causing 5S failure H1: less effort from 5S team member causing 5S failure	➢ Group norms ➢ Communication ➢ Cohesiveness ➢ Trust ➢ Individuality	
Hypothesis – 3	$H_{0:}$ High work pressure not leading to failure of 5S H_1: High work pressure leading to failure of 5S	➢ Work overload ➢ Control and organizational culture ➢ Job dimensions	

Method-2 Many companies are not able to successfully implemented 5S despite lots of study available on it (Daraei et al. 2015). To solve this critical factor of implementing 5S and ranking them so it will help company identify root cause

of problem. The ideal approach is to identify 12 critical success factor and include 5 questions in each factor. Therefore, 60 questions in total which are to be rated based on Linkert scale. Here 1= strongly disagree and 5= strongly agree. On basis of cumulative total, we can decide how much the 12 factors effect and which factor lead to unsuccessful implementation of 5S. Moreover, validity of questionnaires can be done through Experts' consultation, Analyzing research background and Content validation method

Method-3 This method is useful in a micro small medium enterprise (MSME) to identify interrelationships existing between identified barriers. In this MSME research conducted is experimental and quantitative in nature. The identification of waste is done through questionnaire. To interpret data accurately statistical tools, time study analysis and Microsoft excel software are used. For, this Interpretative structure modelling (ISM) is used, this modelling is(Attri et al. 2013). is mentioned in detail in research papers and textbooks' model is used when variables are Implicit and complex. Through this model company's manager can know the effects of barriers on 5S implementation. Moreover, Self structured Intersection matrix (SSIM) is used to display various relationships existing between barriers. Thus, the above mentioned is a glimpse of research mentioned from (Verma and Jha 2019).

After 5S implementation following are the tools used for monitoring and controlling 5S methodology.

Stage-1 prepare tool verification report where each rack is given a code number and name of all items is listed. Furthermore, daily monitoring is done to check availability and workability of tool. Table 5. Shown below is a sample checklist to be applied for each rack in each department to prevent misplacement of tool and make set-in-order an organizational habit.

Table 5. Sample on tool verification report

Rack No	Item name	Quantity	Week-1						Week -2					
			Day -1	Day -2	Day -3	Day -4	Day -5	Day -6	Day -1	Day -2	Day -3	Day -4	Day -5	Day -6
1	First aid box	1	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
2	Log book	1	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
3	Design drawing files	1	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒

☒=Indicate item was present in workable condition at its dedicated place.

Stage -2 To allocate a responsible person whose role is to verify tool verification report once in a week.

Stage-3 Manager should schedule internal audit once in a quarter. The audit should be carried out by team belonging from different departments of company.

Stage -4 Department manager should receive and analyze audit report. Furthermore, manager should coordinate with top management for purchasing short fall items.

5.3 Identifying wastes

Although software, checklist and various tests are pivotal for analysis. (Jain et al 2014). Some researchers have identified 7 types of wastes namely transportation, Inventory, motion, waiting, overproduction, overprocessing and defects in a production plant. Through detection and elimination of some wastes production rate and efficiency increases with very minimum investment.(Ananthanarayanan 2006).

6. 5S implementation effect on manufacturing companies

Table 6. result obtained after 5S implementation in various manufacturing industries

Sr. No	Organization type	Results	Reference
1	SMSE company	Average 8% improvement of productivity	(Kuchekar,2019).
2	Polish manufacturing company	50% reduction in machine setup time, 15% reduction in cycle time.	(Upadhye et al. 2010).
3	Metal working company	Improvement in internal communications, less distance traveled by operator and material, fewer mistake in identifying case auxiliary tools	(Costa and Ferreira 2018).
4	Tools manufacturer	60 % free space available	(Mane and Jayadevan 2015).
5	Ceramic manufacturing company	10 % space saving	(Patel and Thakkar 2014).
6	Automotive manufacturing company	Improvement in safety, productivity and quality	(Veres et al. 2018).
7	Automotive Industry	64 % reduction in risk	(Fernandes et al. 2019).
8	Ink manufacturing company	Reduction in tools and material searching time, efficient usage of workplace	(Sukdeo 2017).
9	Bucket manufacturing company	Performance enhancement in various job shops	(Sukdeo et al. 2020).
10	Welding workshop	18.75 % reduction in goods and equipment searching time, 11.20 % reduction in space.	(Rizkya 2019).

7. Conclusion

The study contained review on various tools and techniques used for, identifying barriers to successful Implementing of 5S and practices for sustaining 5S in a manufacturing industry.
5S implementation has found to be effective in workplace organizations. Through the implementation of which there is significant improvement in productivity and efficiency.
The paper contained various software and tools like Likert scale, Survey questionnaire, SPSS software for Successful implementation of 5S methodology.
Moreover, 3 methods were given to identify barriers causing unsuccessful implementation of 5S. These methods are Hypothesis test, Identification of critical success factor and also identifying their impact on unsuccessful implementation of 5S practices and last methods is identifying effects of barriers Though ISM.
Moreover, importance of visual observation for identifying seven types of wastes was mentioned.

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References

Abdulmalek, F., Rajgopal, J., and Needy, K., A Classification Scheme for the Process Industry to Guide the Implementation of Lean. *Engineering Management Journal*, pp. 15–25, 2006.

Agrahari, R., Dangle, P., and Chandratre, K., Implementation of 5S Methodology in the Small-Scale Industry: A Case Study. *International Journal of Scientific & TechnologyResearch*, Vol.4, no.4, pp. 180-187, 2015.

Agrahari, R., Implementation of 5S Methodology in the Small-Scale Industry: A Case Study. *International Journal of Scientific &Technology Research, pp*. 180-187, 2015.

Ananthanarayanan, K., Application of 5S Management System in NDE Laboratory, Indian *Society for Non-Destructive Testing Hyderabad Chapter*, pp. 256–257, 2006.

Attri, R., Dev, N., and Sharma, V., Interpretive Structural Modelling (ISM) approach: An Overview. *Research Journal of Management Sciences*, Vol.2, no.2, pp.3-8, 2013.

Attri, R., Khan, N., Siddiquee, A. and Khan, Z., Quantifying the factors affecting the 5S implementation in manufacturing organisations using graph theory and matrix method, *International Journal of Services and Operations Management*, 2020.

Costa, C., Ferreira, L., Implementation of 5S Methodology in a Metalworking Company, *DAAAM International Scientific Book*, pp.001-012, 2018. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-19-8, ISSN 1726-9687,

Daraei, M. , Hosseini, M., Niksirat, I., and Kianbakhsh, A., Identifying and Ranking the Critical Success Factors Affecting Implementation of 5S. *Identifying and Ranking the Critical Success Factors Affecting Implementation of 5S*, *Vol.2, no.6, pp*-67–73, 2015.

Davis, R., Duane and Cosenza. *Business Research for Decision Making*, 4th edition, Wadsworth Publishing Company, 1995.

Fernandes, J., Godina, R., Matias, J., Evaluating the Impact of 5S Implementation on Occupational Safety in an Automotive Industrial Unit, *Industrial Engineering and Operations Management II. IJCIEOM 2018. Springer Proceedings in Mathematics & Statistics, 281. Springer*, 2019.

Ghodrati, A. and Zulkifli, N., A Review on 5S Implementation in Industrial and Business Organizations. *IOSR Journal of Business and Management*, Vol.5, no.3, pp. 11–13, 2012.

Ghodrati, A., and Zulkifli, N., the Impact of 5S Implementation on Industrial Organizations' Performance. *International Journal of Business and Management Invention*, *Vol.2, no.3*, pp. 43–49, 2013.

Hirano, H., Productivity Press, Oregon, 1995.

Ho, S. and Cicmil, S. Japanese 5-S practice, *The TQM Magazine*, Vol. 8 , no. 1 , pp.45-53 ,1996.

Hulme, G., Jennings, R., Vizard, M., Rasch, M., Ottenheimer, D., and Handelman, M., *Home* Security Boulevard, Available: https://securityboulevard.com/ ,Feb 16, 2022.

Imai, M., *Gemba Kiazen: A common-Sense, Low-cost Approach to Management*, McGraw-Hill, 1997.

Jain, A., Bhatti, R., and Singh, H., Productivity Improvement through 5S Implementation in Indian Manufacturing Industries. *Lecture Notes in Mechanical Engineering*, pp. 535–545.2014.

Khamis, N., AA Rahman, M., Jamaludin, K., Ismail, A., Ghani, J, and Zulkifli, R. Development of 5S Practice Checklist for Manufacturing Industry. *Proceedings of the World Congress on Engineering,* 2009.

Kuchekar, P. Implementation of 5S Methodology in Manufacturing Industry: Case Study, *International Journal of Innovative Science and Research Technology,* Vol. 4, no. 5, pp. 1254-1260,2019.

Mane, A., Jayadeva, C., 5S implementation in Indian SME: a case study. *International Journal of Process Management and Benchmarking*, Vol.5, no.4, pp-483-498, 2015

Michalska, J., and Szewieczek, D., The 5S methodology as a tool for improving the organisation. *Journal of Achievements in Materials and Manufacturing Engineering*, pp. 211–214, 2007.

O'hEocha, M., A study of the influence of company culture, communications and employee attitudes on the use of 5Ss for environmental management at Cooke Brothers Ltd. *The TQM Magazine*, Vol.12, no.5, pp. 321–330., 2000.

Patel, V., Thakkar, H., A Case Study: 5s Implementation in Ceramics Manufacturing Company Bonfring, *International Journal of Industrial Engineering and Management Science*, Vol.4, no.3, pp-132-139, 2014.

Rahman. Implementation of 5S Practices in the Manufacturing Companies: A Case Study. *American Journal of Applied Sciences*, Vol.7, no.8, pp.1182–1189. 2010.

Rai, P., Effectiveness on 5S implementation on performance of organisation, *Abhinav International Monthly Refereed Journal of Research in Management and Technology*, Vol.5, no.1, 2016.

Rizkya, I., Syahputri, K., Sari, R.M., Siregar, I.,5S Implementation in Welding Workshop – a Lean Tool in Waste Minimization, *IOP Conf. Series: Materials Science and Engineering 505*, 2019.

Rojasra, P. and Qureshi, M., Performance Improvement through 5S in Small Scale Industry: A case study. *International Journal of Modern Engineering Research (IJMER)*, Vol.3, no. 3, pp. 1654–1660, 2013

SafetyCulture, Available: https://safetyculture.com/, Accessed on Feb 16, 2022.

Salunkhe, R., Kamble, G. and Malage, P., Inventory Control and Spare Part Management through 5S, KANBAN and Kaizen at ABC Industry. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, pp. 43–47, 2015.

Sukdeo, N., Ramdass, K., and Petja, G., Application of 7S methodology: A Systematic approach in a bucket manufacturing organisation, South *African Journal of Industrial Engineering*, 2020.

Sukdeo, N., The application of 6S methodology as a lean improvement tool in an ink manufacturing company. *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*., 2017.

Taber, K., The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, pp, 1273–1296, 2017.

Upadhye, N., Deshmukh, S., Garg, S., Lean manufacturing system for medium size manufacturing enterprises: an Indian case, *International Journal of Management Science,* Vol.5, no.5, pp.362-375, 2010

Veres, C., Marian, L., Moica, S., Al-Akel, K. (2018). Case study concerning 5S method impact in an automotive company. Procedia Manufacturing, 22, 900-905.

Verma, R., and Jha, S., Implementation of 5S Framework and Barriers modelling through Interpretive Structure Modelling in a Micro Small Medium Enterprise. *International Journal of Recent Technology and Engineering (IJRTE),* pp. 7010–7019, 2019.

Yogesh, Y., and Kulkarni, S., Study and Analysis of the Factors Affecting Sustainability of 5S. *Study and Analysis of the Factors Affecting Sustainability of 5S*, *Vol.4,* no.6, pp. 178–181, 2016.

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