5S IMPLEMENTATION IN CRANE MANUFACTURING INDUSTRY

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ABSTRACT:
The Japanese methodology 5S (Sort, Set in order, Shine, Standardize, Sustain) is a systematic approach towards improvement of the manufacturing facility. The paper exhibits the case study of implementing 5S in a crane industry. Majority of the small-scale industries are ignorant regarding these types of methodologies. The prime motive of implementing 5S in the crane industry was to raise the productivity with keeping in mind the safety precautions, with help of appropriate management. Also, this case study shows that we applied a proper shop floor layout, introduced inventories and bins, and did many changes in order to make the industry perfect. The effective 5S implementation results the enhancement in productivity and efficiency.

Keywords: 5S methodology, 5S system, Continuous improvement.

1. INTRODUCTION

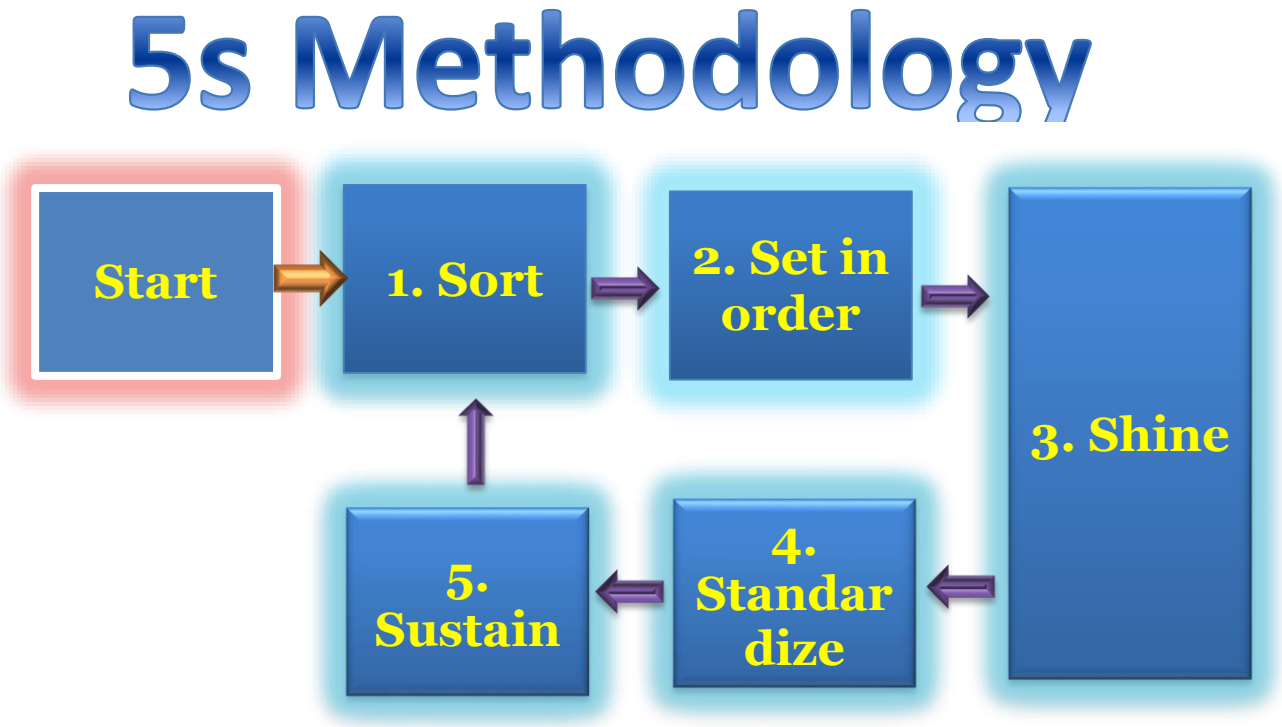
1.1 History of 5S

The methodology was developed in Japan in order to improve the work efficiency, effectiveness, and safety. This systematic technique not only helps to reduce non-value adding time, but also improves productivity and quality [1]. The Japanese methodology 5S is depended on five various pillars: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (Sustain). In past, 5S was known as the Toyota Production System, which was developed by Taiichi Ohno and Eiji Toyoda with Japanese industrial engineers in 1950 [1]. After some new improvements in old system, Sakichi Toyoda (Father of the Japanese industrial revolution), his son Kiichiro and Taiichi Ohno redesigned "TPS" and named as "5S". Venice shipbuilders used similar type of concept for quality assembly of the ship in 16th century. They completed the process in hours rather than completing in days. By the time, the 5S System has expanded and could be found within Total Productive Maintenance (TPM), Just- In-Time (JIT) process, and the lean

manufacturing [1]. There were two frameworks given for applying 5s methodology. Later on, Total Productive Maintenance (TPM), the Just- In-Time (JIT) process, and the lean manufacturing were founded from the base of the 5S work approach. The second framework of 5S was introduced by Hiroyuki Hirano. Hirano's approach was having only "4s", in which Set in order and Shine were considered as a single aspect; whereas, the former framework, presented by Osada, suggested that keeping discipline in the training and education helps to enhance the quality of work as well as work standards. In 1996 Henry Ford introduced CANDO (Cleaning up, Arranging, Neatness, Discipline and Ongoing improvement), which is also a similar system like 5s methodology.

1.2 Basics of 5S

Figure (1): 5S Methodology



1.2.1 ***Sort (Seiri):*** SORT defines the proper arrangement of everything. The main aim of sort is to organize the working environment [8]. The things should be sorted according to their needs and time frequency of working. Another main objective is to remove all the unwanted or not needed items from the working area.

1.2.2 ***Set in order (Seiton):*** SET IN ORDER is the method by which we arrange the things according to the necessity or the flow of the process [8]. The main objective is to follow the work order. It helps to reduce the searching time and improve the utilization of the time and work.

1.2.3 ***Shine (Seiso):*** SHINE refers the systematic cleaning on the regular basis. Cleanliness means higher visibility, visible results, and the high quality of work [8]. The aim is the items, which are out of place or missing, should be recognized easily as well as the hazards or difficult situations can be understood and accounted easily.

1.2.4 ***Standardize (Seiketsu):*** To create appropriate guidelines for sort, set in order, and shine is called STANDARDIZATION [8]. The purpose of it is to create best practice for members in system along with communicable and easily maintainable standards.

1.2.5 ***Sustain (Shitsuke):*** SUSTAIN comes last because, for implementation of sustain first we have to implement other 4S [8]. The goal of sustain is the members of the system get habituated the implemented system. Sustain teaches the discipline and keeps the process running.

1.3 Organization Introduction

"AKASH ENGINEERING WORKS", which was established in 2002, is one of the reputed crane industries in Gujarat. In the time of beginning, it was a small-scale industry, but now, because of many new customers, they are successfully converted into medium scale industry. The organization is the leading manufacturer of service provider of all the cranes. Also, they provide maintenance as well as distribution of crane spare parts. AEW generally manufactures E.O.T., H.O.T., Crane hoist and Goods lift. The industry has the ground area of 8850 square ft. Moreover, in the organization, they use Production flow layout and for manufacturing of the industrial crane, they use batch production system.

2. PROBLEM STATEMENT

- The biggest issue with the industry was poor control over the inventory. The inventory was not arranged in proper manner, so the time taken for any operation was very high, which was causing the decrement in productivity. Also, the problem of the storage limitation was also one of the major concerns, which affects the work efficiency.
- Secondly, there was no proper Shop Floor Layout in the industry, which was also a big concern. Due to absence of shop floor layout, the handling of material was too poor, which influences the quality control.
- Also, unnecessary materials were spread on the floor area by the workers and these items were not properly put to their respective places by the workers.

- Workers were doing their work without wearing any type of safety equipments. They were not habituated of the safety shoes and safety glasses whenever they do the operations, which might cause the serious accidents.
- Moreover, proper assembly area was not occupied in the layout and the space utilization was also not done in appropriate ways, which were the major causes behind low productivity.

Image (2.1): Unorganized Layout

3. LITERATURE REVIEW

- Mayank Dev Singh et al. (2015) conducted the study at "Sandvik Asia Pvt. Ltd, Mehsana, Gujarat" with the prime aim of reducing the abnormality. Also, the waste of time, motion and improper materials handling were the big difficulties they faced on early stages [3]. In order to solve this query, they implemented 5S methodology and they used manual sorting of material and provided the stopper at fallen down area. Additionally, a specific place was introduced for air gun. After implementing lean manufacturing and 5S, the searching time was reduced to 5-6 minute from 14-16 minutes. They saved 640+ pages per year by providing updated preventive maintenance system. By utilizing standardized operation methods, it is possible to reduce human movements in the shop floor.
- How 5S strategy implemented in any industry, Kaushik Kumar et al. (2012) described the steps for it. With the proper calculations, authors mentioned that lean tool is very beneficiary for the improvement of the productivity in any organization [4]. They mentioned in detail how and when

5S can be implemented. Literature gives the detailed idea about the Sort, Set In order, Shine, Standardize and Sustain. They also stated the various benefits of the system according to industry, so it can be known exactly how and when to apply this methodology.

- The research carried out in a Malaysian Automotive Parts Manufacturing by Nadirah Roslin et al. (2012) described the progress in its early stages of lean manufacturing implementation [5]. The literature suggests that there are few critical success factors such as availabilities of resources, organizational culture and information technology proficiency which impress each dimension of lean manufacturing. The observation of lean success determinants is limited to this case and care should be taken while generalizing the results of this case study to other Malaysian manufacturing organizations. Thus, future studies of multiple case studies can be conducted to get the influence of a variety of success factors for different lean manufacturing tools.
- Gheorghe Dulhai (2008) conducted a study at the manufacturing unit of the auto car exhaust. The aim of the study was to improve manufacturing of the auto car exhaust by various methods like 5S and continuous improvement. They used the questionnaires in order to examine the tasks. After implementation of this 5S strategy, the accidents got reduced. The maximum days they maintained safety [6] till 56 days. Reduction of physical efforts and fewer accidents during the production process were obtained. The results were appeared in short time around couple of weeks.
- In the Hari Bio-Mass Processing Unit, K Ramesh, and team (2014) conducted the study for reducing the waste and removing unwanted activities in the biomass plant. They diagnosed the current flow of the organization in order to implement the transparent process flow. They trained labors and supervisors for minimization of the waste. Document analysis and result reported that after implementation of 5S, the industry achieved the clean work space. Also, they washed the walls to enhance the working environment. As a result, the unwanted activities were reduced, floor layout became neat and clean and approximate 700 kg of excessive scrap got reduced [7].
- By performing the test in the industry, S.R. Dulange (2013) wanted to enhance the textile market in the country with help of cutting-edge management methods in power looms. They did the analysis of the lack of production tools, improper management, and many others. These all things were done by the audit team which was created for the data collection [9]. To sort the items, they utilized the colour coding method and also various tags were used in power looms too. Moreover, the bins were used in order to maintain appropriate material flow. Upcoming 30 weeks were the analysis time after applying this system. Consequently, the improvement in productivity was achieved. That is why the Solapur Textile Sector was upgraded in the matter of management and productivity.

- R.T. Salunkhe et al. carried out the study to cut out the searching time of the spare parts in the industry. In the ABC industry, the lean manufacturing tools such as Kaizen as well as 5S were taken into the action to curb the issues. There were many unwanted items, which were kept in any bins, so the bins did not carry the appropriate objects. They segregated the places of pipe and hoses in variety of racks [10]. By applying 5S methodology the enormous changes came in the searching time because the bins got the colour codes. Where the searching time was somewhere around 13-15 minutes before, now it dropped to 6-8 minutes. Eventually, they gained over the inventory control by maintaining minimum level of self-life items.
- Abhay R. Kobarne, et al. (2016) exhibited one of the major issues in the company. As per their reports, they found that inadequate communication, less contact in the organization. Due to that, the management took some hard commitments [11]. It was told to all that more and more cooperation from all level of laymen is much needed during the implementation period. Finally, by some strict implement, the results started to come satisfactory. Moreover, they found that continuous training is the basic as well as most important aspect in order to change the organization's environment. They also understood that Periodic assessment should focus on the enhancement and development regarding all inputs in the organization. At the end, some fruitful results were obtained.
- Rastogi Vikas et al. (2014) figured out that some of the top organizations have already applied some features of the 5S in their regular activities without total awareness of its pros. However, other investigations are required to implement the 5S as a continuously improving tool in company. They identified that size and structure are the aspects which not only can affect the application of the 5S but also its effectiveness. Moreover, they conceive that this methodology is not new, and they have had it for very long period of time. They also said that they need the 5S at their workplaces as majority of the individuals do their works without thinking and as all know that 5S can be a reflection of the behaviors of people. Hubbard [12] exhibited that orderliness helps to stop three types of waste: searching waste, difficulty-of-use waste, and the waste of returning items to their proper place. Eventually, it was understood that 5S implementation is not possible without appropriate training that make the place standardized. Hence, it is perceived that continuous training is very crucial in order to alter the environment of the company.
- Harsha Lingareddy et al. (2013) carried out their research in metal doors manufacturing industry. They implemented 5S in various stages, where in primary phase they did their research in item selection in production process as the objects were in haphazard manner. They believed that 5S methodology depends on the capacity of constructing and maintaining a well-managed, clean, effective, and high quality work place [13]. Additionally, they worked over shop floor layout too,

in which they created questionnaire for the workers. Eventually, they got amazing outcomes like better use of workplace, no losing of tools, maintenance cost reduction, safety enhancement, reduction in travel time and improved working conditions. They found the rise in efficiency of every aspect in the industry as the workers did their job appropriately.

- Vaibhav Bharambe et al. (2020) (Same authors of this paper) reviewed many research papers of 5S implementation in various organizations [14]. The detailed review of the research papers, from various organizations like manufacturing industry, college, temple and many more, has been done.

4. IMPLEMENTATION OF 5S

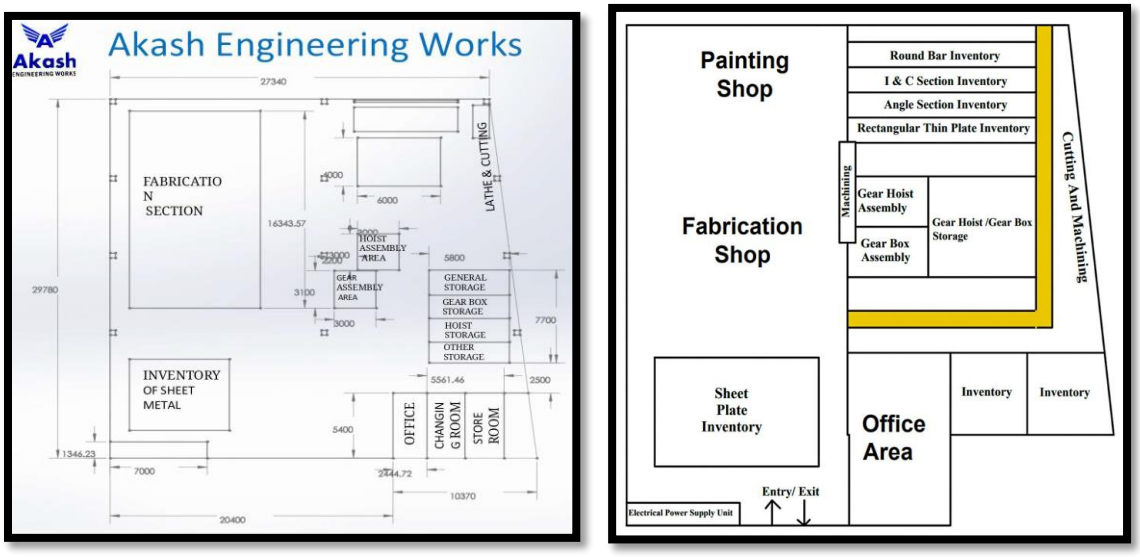
- Inventory control was the biggest problem in the industry. All materials, which were coming for assembly work; the workers were putting them anywhere in the inventory room. There was no specific location decided for systematic arrangements of raw material. We firstly did the analysis of the need of materials and designed the systematic racks accordingly in the industry. In that, we sorted the materials in three different stores. One for Gear hoist assembly, second for Gear box assembly and eventual one for electrical panel equipment stores.

Image (4.1): Improper Arrangement of the Materials

Image (4.2): Proper Arrangement of the Materials

- As per above images, we can see that in the before time the couplings, gears, welding rods boxes were placed on the floor and the things which were placed on the racks were also nasty and not easily indentified. In order to improve all that difficulties, we redesigned the racks in such a way that all the materials get organized in the rack. For easy identification, we used the name plates for each material. Also, in racks, we segregated different TONS of gears in same rack but in ascending order of it. To solve the disarrangement of bearing and keys, we used the bins and segregated them according to the size.

Figure (4.3): Old-New Plant Layout



- As we were in early stages, there was no proper shop floor layout in the organization. Due to that the space related issues in assembly of gear hoist and gear box were occurring. To resolve those issues, we implemented new process layout according to the data included the movements of the workers and traveling flow of the material. During designing new layout, we gave proper space for assembly operations, walkway, and machining area. We constructed walk way in such manner that no worker gets harmed during walking on that path. Industry affected immensely after implementation of new shop floor layout. Now workers and other people can walk fearlessly on the walkway, which enhances the discipline in the company.

Image (4.4): Floor Markings

- We conducted safety awareness sessions for the workers' safety. In these sessions, we showed them the videos and pictures and explained that how the things might become worst if the safely is compromised. Also, we provided them the helmets, gloves, and glasses for their own safety. Additionally, we applied the siren in the shop floor. So, in case of emergency or anything hazard happens, they can press the buttons and all the workers can immediately stop their work and can go to the safe place. For spreading more awareness about 5S and safety, we hanged the posters and various banners, so the visual images can motivate the workers and they become self-aware about safety every day.

Image (4.5): Before & After Providing the Helmets

Image (4.6): 5S Safety Tags

5. RESULT ANALYSIS

5.1 Sort Rating:

Sort is the first step of the 5S methodology. For calculation of sort rating [2], we allotted 5 regions for sort arrangement, and we decided that the system should achieve at least 2.5 out of 5, which shows that the implemented system is 50% active.

Following are the Sort rating criterion.

(1) Material Availability :
Give '1' marks if necessary, material for assembly is available, if not then mark it '0'.

(2) Material Sorting:
Give '1' marks if material for assembly is sorted in its allocated place, if not then mark it '0'.

(3) Gas Cylinder Sorting:

Give '1' marks if empty gas cylinder and filled gas cylinder are sorted in its allocated place, if not then mark it '0'.

(4) Tools Sorting:

Give '1' marks if cutting, measuring, and fitting tools are sorted in its allocated place, if not then mark it '0'.

(5) Waste Elimination:

Let total 'F' number of waste are listed but only 'E' was eliminated the marks of elimination process will be Fraction of waste elimination = [E/F]

Table (5.1): Sort Rating

Sr. no.	**Durations**	**Material Availability**	**Material Sorting**	**Gas cylinder sorting**	**Tools sorting**	**Waste Elimination**	**Total Rating**
		0 or 1	0 or 1	0 or 1	0 or 1	[E/F]	
1	14 Feb 2020	1	0	0	1	0.6	2.6
2	20 Feb 2020	1	1	1	0	0.6	3.6
3	26 Feb 2020	1	1	1	0	0.6	3.6
4	04 Mar 2020	1	0	1	1	0.8	3.8
5	09 Mar 2020	1	1	1	1	0.8	4.8
6	15 Mar 2020	1	1	0	1	0.8	4.8

5.2 Set In Order Rating:

Set in order is the second step of the 5S methodology. It deals with the proper arrangement of the tools, material, and processes [2].

Following are the Set-in order rating criterion.

(1) Inventory material arrangement:

Give '1' marks if all outsource material are arranged in its allocated place, if not then mark it '0'.

(2) Flow path of assembly is followed:

Give '1' marks if suggested assembly flow path is followed, if not then mark it '0'.

(3) Taking material for assembly:

In this process, labor comes to inventory for taking parts, which he will use for assembly. Let total 'B' number of parts is required for assembly. Where 'A' shows that out of total requirements how many parts he took from inventory.

Fraction of material took = [A/B].

(4) Tools sequencing Rating:

This shows that the consistency of the fulfillment of the requirement of the tools. Let 'C' be the numbers of tools irregular arrangement of tools, 'D' proper tool arrangement in sequence.

Fraction of consistency to tool arrangement: [C/D]

(5) Flow process of assembly is followed:

Give '1' marks if suggested assembly process flow is followed, if not then mark it '0'.

Table (5.2): Set In Order Rating

Sr. no.	**Durations**	**Inventory material Arrangement Rating**	**Flow path of assembly follow Rating**	**Taking material for assembly Rating**	**Tools sequencing Rating**	**Flow process of assembly is follow Rating**	**Total Rating**
		0 or 1	0 or 1	[A/B]	[C/D]	0 or 1	
1	14 Feb 2020	1	0	0.55	0.6	1	3.15
2	20 Feb 2020	1	0	0.55	0.6	0	2.15
3	26 Feb 2020	1	1	0.7	0.8	0	3.5
4	04 Mar 2020	1	1	0.7	0.8	1	4.5
5	09 Mar 2020	1	1	0.8	1	1	4.8
6	15 Mar 2020	1	1	0.8	1	1	4.8

5.3 Shine Rating:

Shine is the third step of the 5S methodology. It deals with the working environment of the shop floor with proper cleaning on the work space [2]. For that we allocated the rating in five criterions.

Following are the Set-in order rating criterion.

(1) Machine cleaning rating:

Give '1' marks if machine is cleaned after every set period of timing, if not then mark it '0'.

(2) Walk way cleaning rating:

Give '1' marks if walk way is cleaned during assembly, if not then mark it '0'.

(3) Working Environment:

Give '1' marks if air, water, washroom, lighting conditions are good, if not then mark it '0'.

(4) Cleaning Consistency rating:

Let total 'G' cleaning not on shop floor during every set period of timing. And 'H' for total set period of cleaning required. Fraction of cleaning consistency = [G/H].

(5) Safety from accidents rating:

Let total 'I' accidents occurs during auditing because of safety compromise. And 'J' for total number of safety norms created to require the accidents. Fraction of safety from accidents = [1-{I/J}]

Table (5.3): Shine Rating

Sr. no.	**Durations**	**Machine cleaning rating**	**Walk way cleaning rating**	**Working environ-ment**	**Cleaning Consistency rating**	**Safety from accidents rating**	**Total Rating**
		0 or 1	0 or 1	0 or 1	[G/H]	[1-{I/J}]	
1	14 Feb 2020	0	1	0	0.25	0.2	1.45
2	20 Feb 2020	0	1	0	0.5	0.4	1.9
3	26 Feb 2020	0	1	1	0.5	0.6	3.1
4	04 Mar 2020	1	1	1	0.75	0.6	4.35
5	09 Mar 2020	1	1	1	0.75	0.8	4.55
6	15 Mar 2020	1	1	1	0.75	0.8	4.55

5.4 Standardize Rating:

Standardize rating will be got by calculating the average of previous three 'S', because standards of any system will rise and fall by mean rate depending factors [2].

$$Standarize\ rating = \frac{\text{Sort} + \text{Set in order} + \text{Shine}}{3}$$

Table (5.4): Standardize Rating

Sr. no.	**Durations**	**Total Rating = [{S1 +S2 + S3}/3]**
1	14 Feb 2020	2.4
2	20 Feb 2020	2.55

3	26 Feb 2020	3.4
4	04 Mar 2020	4.21
5	09 Mar 2020	4.71
6	15 Mar 2020	4.71

5.5 Sustain Rating:

Sustain rating depends on the previous four 'S', because without that the regularity will not be maintained. Therefore, Sustain rate will be the average of previous four 'S' ratings [2]. By following the instructions accurately, we can maintain the machine condition at its peak level, which may help for better production and stay away from breakdown.

(1) Removing small faults through the aid of cleaning.

(2) Providing the execution of visual control.

(3) Providing the performance of protective activities.

(4) Granting the responsibility of the machine to the operator.

(5) Formation of a disciplined company.

Table (5.5): Sustain Rating

Sr. no.	**Durations**	**Total Rating = [{S1 +S2 + S3 +S4}/4]**
1	14 Feb 2020	2.4
2	20 Feb 2020	2.55
3	26 Feb 2020	3.4
4	04 Mar 2020	4.21
5	09 Mar 2020	4.71
6	15 Mar 2020	4.71

5.6 5S System Efficiency:

After implementing 5S, the immense changes in the industry have come. In the initial stage the efficiency was very less. However, week by week the numbers of system efficiency were rising gradually. Eventually, we achieved almost near to double efficiency of the initial one. The industry got many benefits after implementation, which clearly shows the successful implementation of 5S in the industry.

Table (5.6): 5s System Efficiency

Sr. no.	Durations	(S1+S2+S3+S4+S5)*100 / 25	Efficiency (%)
1	14 Feb 2020	(2.6+3.15+1.45+2.4+2.4)*100/25	48.00%
2	20 Feb 2020	(3.6+2.15+1.9+2.55+2.55)*100/25	51.00%
3	26 Feb 2020	(3.6+3.5+3.1+3.4+3.4)*100/25	68.00%
4	04 Mar 2020	(3.8+4.5+4.35+4.21+4.21)*100/25	84.28%
5	09 Mar 2020	(4.8+4.8+4.55+4.71+4.71)*100/25	94.28%
6	15 Mar 2020	(4.8+4.8+4.55+4.71+4.71)*100/25	94.28%

6. CONCLUSION

The 5S system implemented in this crane manufacturing industry is found to be adequate due to many benefits such as the wastes, scraps and losses were minimized, over production stocks were controlled with flexible work stations. The 5S is an effective management tool which can improve housekeeping, environmental conditions and health and safety standards.

SORT

- The materials or parts' finding time declined and it helped to make easy the material handling in the industry.
- Also due to sorting of all materials or parts, they are now easy to access and store in the inventory.
- Waste sorting improved the handling of waste material.
- Sorting of assembly processes and workers also improved the plant productivity.

SET IN ORDER

- Sequencing of the raw material/parts in inventory storage helped to minimize the time of decision of the worker.
- Set the order for the assembly operations of the product helped to shorten the unwanted activities.

SHINE

- By introducing Periodic Routine Method, the regular checking of objects is done. Also, the things like colors, containers and other wet things are periodically checked. Hence, the leaking can be avoided, and clean floor area is achieved.
- Now, after removal of the wastes and dust on the floor area, the working environment became positive inside the industry.

STANDARDIZATION

- Standardization of the flow of the assembly of the product is done. Due to that, we saved **27 minutes and 102 meter** travel distance of the gear hoist in total assembly timing and travel distance respectively and for gear box we saved **28 minutes of time and 45 meter** travel distance from total assembly of gear box.
- Siren and face scanners made the workers self-disciplinary. These objects made the workers to be on time and to do their respective work by maintaining the discipline in the industry.

SUSTAIN

- Workers are feeling motivated because of the standardized process and due to safety tags/banners, now they follow the safety rules. We organized the safety awareness programs one to one for workers, so that the workers were got aware about safety.
- Also, we ensured sustaining sorting, storage, and shining activities every day. For monitoring all the systems, we conducted the internal audits and the results are very satisfactory.
- Due to all this 5S practice, discipline in the process has been improved and workers are now also became disciplined.

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