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Implementation of Ishikawa diagram to enhance the Productivity of Coal handling section of a thermal power plant

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Abstract

Over the years, extensive research has been done on quality management (QM) and its techniques. Many quality tools and approaches may be adopted to improve the quality and productivity. The primary aim of this research is to implement the quality management tools and techniques comprehensively to increase the productivity of a thermal power plant. It is evident from the literature that Ishikawa (Cause and Effect) diagram is one of the most commonly used tools. Some of the significant problems of thermal power plant have been discussed and subsequently, their possible solutions are also recommended.

1. Introduction

The quality of a product is a measure of its performance, reliability and durability. It is also a parameter that differentiates a product from its competitors. Quality is both a philosophy and a process for improving consumer contentment, reducing cycle time and costs, eradicating flaws, and perfecting a product with the use of a set of predetermined tools. Quality products also ensure long term earning and profitability.

As the term suggests itself, managing the quality of a product is Quality management (QM) but it is not as straightforward as it sounds. There are many steps and procedure involved to ensure the optimum quality management. Quality management has been one of the main focus for decades now and many a research have been done so far and continue to be done. There have been so many tools and methods to manage quality of a product (or service) and to improve it now.

The main aim of QM is to improve the outcome (product or service). In other words, the superior quality of the product is achieved. It helps in reducing cycle time and costs. QM ensures increased revenues and productivity of the organisation. It also helps in reducing waste and manage the inventory efficiently. QM enables the employees to work closely with the suppliers as well as the customers.

1.1 Quality Management Tools

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Some of the traditional quality management (QM) tools were first emphasised by Kaoru Ishikawa. Conventional QM tools such as the Fishbone diagram (cause and effect diagram), check sheet, histogram, graphs, control chart, scatter diagram, Pareto chart, and stratifications are very useful for the industries and service sector also.

(i) Fishbone diagram: Also known as Ishikawa diagram or "cause and effect" diagram, this is one of the most commonly used tool. It is used to represent the "causes" or the reasons why a particular problem has occurred (the "effect"). The causes are further classified into branches of man, material, method, environment, and machine. It plays a significant role in identifying the root causes of a specific problem.

(ii) Histogram: Another one of the mostly used and popular tools is histogram. This tool is simply a graphical representation of numerical data based on frequency distribution.

(iii) Graphs & Charts: Bar charts, Pie charts and their various versions are used to represent the data and compare many aspects of a problem simultaneously which makes it easier to understand.

(iv) Control charts:A control chart is a graph that is used to assess how much a process evolves over time. When current data is opposed to prior control limits, it is possible to determine if the process variance is consistent (under control) or random (out of control).

(v) Pareto chart: This is used to recognize the problems, prioritize them and also noting their frequency in the entire process. It is often represented by a combination of a bar chart and a line graph depicting the most common causes of the problems and their frequency in order to rectify the defect occurred due to the same.

(vi) Check-sheet: It is an organised, fully prepared form for gathering and processing data; a generalized instrument that may be tailored to a wide range of applications.

1.2 Modern Quality Management Tools

Six Sigma, lean six sigma, total quality management (TQM), Kaizen are some of the modern QM tools to implement in an organisation.Some of themare as described as below:

(i) **Kaizen**: The word in their native language i.e, Japanese means "kai" = change and "zen" = good. Kaizen philosophy means improving continuously and everyone from an executive to an apprentice is responsible for the success of their product. Continuous small improvement leads to eventual success.

(ii) **Six Sigma**: This is a method where the goal is to eliminate defects and minimise and eventually remove the variation completely to have a superior product. According to six sigma, any product that is not up to customer's satisfaction is considered as a defect and should be removed.

There are two Six Sigma methods:

a) DMAIC: design, measure, analyse, improve, control
b) DMADV: design, measure, analyse, design, verify

(iii) **Lean manufacturing:** The methodology where the main focus is to minimise waste in the system. Lean practices are often used in organisations.

(iv) **Lean Six Sigma**: A combination of six sigma and lean manufacturing which encourages the people to systematically remove waste.

(v) **Total Quality Management**: It is more of a management approach that involves the entire organisation from the management to staff to customer. A strategic and systematic approach where decisions are based on a facts such as performance of the process and is customer focused.

(vi) **Quality management system (QMS):** A system where a formal set of processes, procedures and documents are required to fulfil in order to maintain the quality of the said system. ISO 9001 is an international standard that is associated with quality management and is used for certification and accreditation purposes.

1.3 Literature Review

McQuater et al. (1995) summarized the critical aspects in the efficient implementation of quality management tools and techniques in a continuous improvement process. Investigation of several of the most prevalent challenges faced during utilisation as well as strategies for overcoming and mitigating them has been done. A “health check” for evaluating tools and techniques has also been proffered. A study was done by Sousa et al. (2005)where a comprehensive review of literature was done. With the help of a questionnaire survey, level of use of quality tools and determination of their performance was ascertained in small and medium scale industries in Portugal. The collected data was then, analysed in SPSS and results were concluded. The various performance measure have been discussed and the obstacles in adopting the tools have been identified with the help of the study. It was established that graphs were the most widely used tool followed by process flow charts and check sheet.

Rahman et al. (2010) investigated about the implementation of 5S practices in manufacturing industries. It was established that an audit is a good way to evaluate the implementation. For this, two companies were selected and the audits were conducted and comparisons were made. Though both companies had employed the practices well, still some issues like improper organisation of tools and equipment were noted. The companies strongly agreed that adopting 5S practices was highly beneficial and top management played a crucial role.Arya & Choudhary (2015) examined the effects of implementing Kaizen in small- scale manufacturing industry. For this, data was collected by weekly visits to the industry. Quality tool like fishbone diagram was used to analyse the data and identify the main problems. Following this, kaizen events were applied in every department. As a result, the layout was modified to reduce the machining time. It was observed that after the implementation, workplace was cleaner and the cost was reduced due to easy access to the inventory.Ehie & Gilliland (2016)analysed the data collected from six terminals under a motor carrier industry regarding delivery inconsistencies using quality management tools. Pareto analysis was used to pick out the major causes. Next, a cause and effect diagram was created to identify the sub- causes. Damage and shortage were found to be the major problems by the company. The control charts were used to graphically indicate that some of the terminals had the problems in control while others did not. Correct supervision, proper training to employees and the packages were labelled correctly are some of the recommendation that were employed in the terminals. Substantial decrease in the delivery inconsistencies was observed.

Singh et al. (2018)conducted a study to evaluate various lean manufacturing tools adopted in manufacturing industries in northern India. The level of importance of different lean tools and their benefits after successful implementation to enhance the performance of the companies are discussed in the paper. A survey was conducted to determine the importance and the contribution of 23 chosen lean tools. The data collected was then analysed in SPSS and JIT was found to be the most important lean tool that can increase productivity and minimise the rejections. A case study was done where JIT was implemented with 5S was applied. The data was collected again after the implementation to show an increase in overall production rate of the industry in terms of the total cost reduced. Kumar et al. (2018)implemented Kaizen and other quality tools in a SME in India. The existing conditions were noted and current state map was prepared. Takt time was calculated and compared with the existing one."5whys" method was applied to determine the root causes and subsequently, 2 Kaizen events were suggested. In the first Kaizen event, poka-yoke technique was used to control the variation and in the second kaizen event, brainstorming was employed to eliminate the roughness on the surface of the product. It was observed that inventory level, lead time and cycle time were reduced and quality of the product was improved.

Kumar & Prajapati (2019)employed quality tools such as Pareto chart and fishbone diagram to a railway carriage manufacturing company in Northern India to identify the root causes of breakdown of the parts and enhance the quality of the products. From the Pareto chart, it was observed that the defects in the control arms were the highest, followed by Anker link block. It was also noted that there were issues within the assembly lines. Since, there were several stages of operations involved, the chances of defects were high thereby needing an improvement in the quality. A study was done by Sony et al. (2019)where Lean Six Sigma (LSS) tool, DMAIC (Define-Measure-Analyse-Improve-Control) was used in 5 different case studies in power sector, i.e., generation, transmission and distribution. 3 out of the 5 case studies show economic benefits were increased as the electricity losses were reduced. Decrease in downtime leading to customer satisfaction. Also, it was seen that there was decrease in consumption of demineralized water contributing in generation cost reduction.

A study was presented by Sharma et al. (2020)to provide insight into the implementation status and applicability of various Quality tools and techniques in manufacturing and service organisations. A questionnaire survey was distributed among organisations to collect information and statistics. The questions were about the application and advantages of Quality tools and techniques as well as the prevalence of those who do not adopt them. SPSS was used to analyse the data. Around 40% of the respondents felt that implementing quality tools improve productivity and efficiency. The Shepard plot was utilised to outline the adaptability of tools and techniques. Lastly, the challenges in executing the tools like lack of knowledge, training, resources, communication and financial issues have been discussed. Senthilkumar & Nallusamy (2021)applied lean manufacturing tools and techniques to increase the quality and productivity in the rubber moulding industry. Data were collected for three months through time study before the implementation. OEE was calculated and losses and wastes were determined in the processes. TPM, E- Kanban and JIT were executed, and satisfactory results were observed. Productivity increased by 10% and OEE by 25%. E-Kanban implementation minimised the inventory level. Reduction in defects, and a decrease in the cost, as well as machine downtime, was apparent.

1.4 Introduction of Industry

The company that has been selected for the study is a thermal power plant located in Northern India owned by NTPC Ltd. The major departments of the thermal power plant include human resources (HR), operations & maintenance (O&M), services, fuel management, ash handling and few other smaller departments to ensure a smooth and efficient operation of the plant.

(i) Human resources department: This department is concerned with the management of the employees and various facets of employment such as recruitment, interviewing, labour laws, keeping the employees files updated.

(ii) Services: Services department comprises of sub- departments such as finances, IT, Business Excellence (BE) and medical service.

- Finance department deals with employees' salaries, any contracts related to the plant and other monetary matters.

- IT department is responsible for the management, safety and security of the data stored in the computer systems of the plant, network architecture (inter and intra- plant) and making sure that the whole network is running smoothly and easily accessible to the employees.

- Business Excellence (BE) is the department that is focussed in implementation of various quality management tools and techniques effectively and efficiently in the plant. They are concerned with the overall performance and the factors affecting it.

- Medical services provide the medical facilities and regular check -ups of the employees. They also conduct various seminars and webinars to educate the employees and their family about the different topics to keep them healthy and in shape.

(iii) Training Center: This department focuses on the training aspect of new as well as existing employees. The average number of hours of training per year is one of the tasks employees are required to do to keep up with the technological advancements.

(iv) Auto base: This department is responsible to provide vehicles for the transportation to employees for official work.

(v) Chemistry: This department is focussed mainly on collecting and testing the water sample and supplying de-mineralised water (DM water) to various locations in the plant such as the boiler and cooling tower. The raw water is collected from a nearby water source and treated and converted to DM water. This department is also responsible to neutralize the effluent (sludge) that comes out of the plant before it is released back into the environment.

(vi) Operation & maintenance (O&M): This is the largest department that is concerned with all the operations done in the plant and the maintenance required to keep the plant running efficiently.

- Operations section include Control Room and Switchyard that oversee all the operations at different points in the plant. Operation department is also accountable for the orderly functioning of the Boiler, Turbine, Condenser, Cooling Tower, common auxiliaries like cooling water pump, compressor and raw water.

- Maintenance department focusses on the control & instrumentation (C & I), mechanical and electrical maintenance in the plant. It is also in charge of the upkeep of boiler, turbine and off-site operations like cooling tower.

- Maintenance planning: This department only focusses on scheduling of the maintenance of all the equipment at the appropriate time. It involves short as well as long –term planning. It coordinates daily planning meeting with the General Manager (head of the whole plant) and O & M department. Breakdown, preventive and sometimes, emergency maintenance are all planned by this department.

- Energy Efficiency Management Group (EEMG) and Environment Management Group (EMG): These are the departments that collect the data concerning the energy consumption and environmental effects of the plant respectively. Their goal is to minimise the adverse effects. EEMG is the division that works towards the goal to minimise the auxiliary power consumption (APC) of the plant.

- Fuel management (FM): This department is accountable for providing all types of fuels that are required by the plant. For coal based plant, FM is in charge of procuring the raw coal. This department further is classified into Coal Handling Plant, Coal Coordination (CC) and Mary Go Round (MGR). CHP is the second biggest department in the plant and is responsible for receiving raw coal and turning it into the suitable size that can be fed into the bunker of the boiler. MGR and CC are in charge of receiving the raw coal from the source mine through railways.

- Ash Handling, Management & Utilisation: This is the unit that deals with the fly ash management. They are also involved in the planning of optimum utilisation of ash in the form of various products such as bricks, filing material and tiles for the floor.

Since, the study is about the quality management, a unit of the power plant was focused on, that is, coal handling plant. The next sub-section focuses on the Coal Handling Plant (CHP) and its operation.

1.5 Coal Handling Plant (CHP)

The main objective of Coal Handling Plant (CHP) is to supply a constant flow of fuel (coal) from the source (coal mines) to the power station after processing it.

Transportation of coal is done by various methods such as rails, roads, aerial ropeways or conveyor belt. After reaching the power plant, it is either stored in storage yards or fed to the boilers to start power generation. If due to some issues, transportation system fails, there must be sufficient coal stock available in the stock/ storage yard so the power generation is not interrupted. The role of CHP is not only to receive and unload the coal but also to keep the stock at a certain level so the power generation plant works smoothly. This is possible when availability and utilisation of the equipment is properly exercised. The process flow of Coal Handling Plant (CHP) is depicted in the Figure 1.

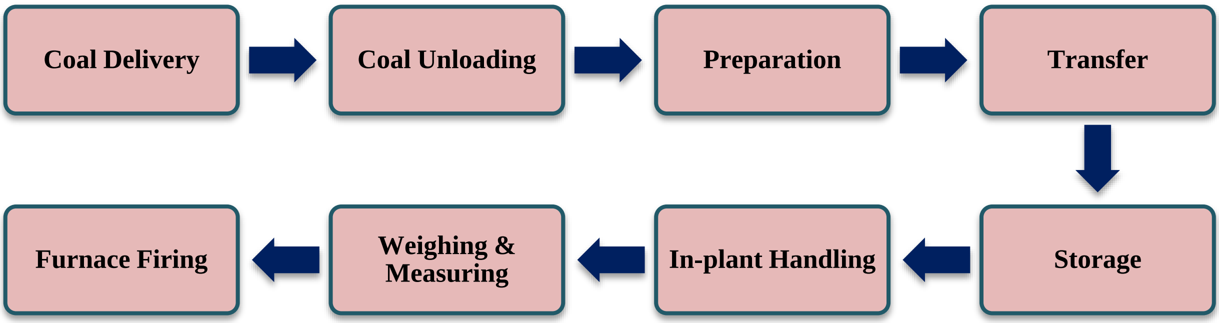

Figure 1. Process flow of Coal Handling Plant*(Source:* *www.theengineerspost.com)*

The processes and major equipmentsinvolved in CHP have been discussed as follows:

1. **Coal Delivery**

Coal is transported through various modes, that is, through railways, roadways, pipelines, sea or river and ropeways or aerial tram. It all depends on the distance between the source mine and the destination power plant and the quantity of coal being transferred. In this case, railways are used for the smooth transportation of required coal to the thermal power plant.

2. **Unloading Process**

The coal is unloaded with the help of the appropriate method. Again it depends on the mode of transportation of coal. When the mode is railways, as it happens to be in this case, there are two types of wagon, namely, BOXN and BOBRN wagons. Coal is unloaded from the top of BOXN wagons by tilting it with the help of Wagon Tippler while BOBRN wagons are emptied when the pneumatically driven gates are opened from the bottom in Track Hopper.

(i) **Track Hopper:** This is used to store coal that is unloaded by the BOBRN wagon. It is constructed from reinforced cement concrete (RCC).

(ii) **Wagon Tippler:** It is an apparatus used to unload the wagon with the help of Side Arm Charger (SAC). The wagon is rolled over and the coal is unloaded onto the conveyor belt.

(iii) **Side arm Charger (SAC):** It is used with the wagon tippler to increase the unloading speed.

3. **Preparation of Coal**

After unloading, the raw material, that is, coal as received, is then prepared to be transferred to the storage yard or the boiler bunker. During the preparation, coal is transferred from the apron feeder to the conveyor belt so that it can go to the crusher house. Metal detectors and Inline Magnetic Separator (ILMS) are suspended over the belt to root out the magnetic pieces from the raw coal and extracted immediately following their detection. After this, coal is passed through the vibrating screens called as Grizzly Feeder which sifts through the fine coal and retains the coarse pieces which are then sent to the crusher.

(i) **Apron feeder:**A steel belt that transmits the coal from the bunker to the conveyor belt at a controlled rate of speed according to the boiler requirement.

(ii) **Conveyor belt:** It transmits material, that is, coal from one location to another with the help of pulleys, idlers and structures. This is an appropriate way to transfer a huge amount of coal over a large distance.

The belt is made of fabric. The endless belt is mounted over a pair of end pulleys reinforced with several idlers at regular gap.

(iii) Metal detectors: These are suspended over the belt to detect metal pieces that may be present in the raw coal.

(iv) Inline Magnetic Separators (ILMS): Their function is to automatically extricate and dispense the magnetic and metallic pieces from the raw coal on the conveyor belt.

(v) Vibrating screens: These are a type of filters used to sift through the fine coal pieces that are of the pre-approved size, and the coarser sized or the wet coal that remains on the screens is transferred to the crusher to make it of the appropriate size.

(vi) Crusher: A ring granulator type crusher is used to reduce the large coal rocks into a smaller size of coal of less than 20mm. The raw coal is crushed with a coupling effect of rolling compression and impact on the large pieces.

4. Storage of Coal

After the coal is reduced to the required size, it is then transferred to either the storage yard or the bunker. The process when the coal is sent to the storage yard is known as stacking. This is done when the bunker level is up to its full capacity. The stored coal is sent to thebunker when its level is low. This is known as reclaiming. These processes are carried out by the apparatus called as Stacker (Reclaimer).

5. In-Plant Handling

These are the processes done for the handling of coal between the storage and the bunker of the boiler. The coal is fed into the bunker through tripper trolley. The tripper is outfitted in such a manner that coal can be fed into the bunker on both sides of the conveyor. Coal sampling unit is used to collect samples of coal regularly. Dry fog dust separation and dust particle systems are placed in CHP to keep the quality if air in check and to minimise the fine dust particles in the air.

6. Weighing & Measuring

Conveyor Belt Scale is used to weigh the conveyor belt material, that is, coal. The scale helps in calculating the speed of the conveyor belt at which the coal is being carried. This is done before the coal is fed into the bunker which leads to the firing of the boiler.

Coal is then fed to the mill to be pulverised into the required size before it is utilised in the boiler.

2. Methodology

From the available literature, it is evident that Ishikawa (Cause and Effect) diagram is one the most commonly used quality tool. The Ishikawa diagram is used to identify the "causes" or explanations for any type of defect or inefficiency. It is basically used to illustrate these causes in a graphical depiction. Causes are then, subdivided into sub-causes.

2.1 Procedure to create a Ishikawa diagram

Steps to develop a Cause and Effect diagram are as follows:

Step I A problem is defined, in other words the effect for which the causes must be established.
Step II Brainstorming or a step-by-step strategy is used to investigate plausible causes.
Step III Man, machine, material, method and environment are assigned as the major causes.These are further classified into various observed causes.
Step IV After establishing the sub- causes, any inconsistency is checked in all the major causes.

2.2 Application of Ishikawa diagram for identifying the causes of Coal Handling plant

Even though, the company practices almost all the required courses of action and protocols to ensure the optimum results, there are quite a few problems that still arise occasionally. The "cause and effect" or Ishikawa diagram, has been used to illustrate the problems that employees face in the plant and figure out the possible reasons. The diagram was developed with the help of MINITAB (version 17) software as shown in the Fig. 2.

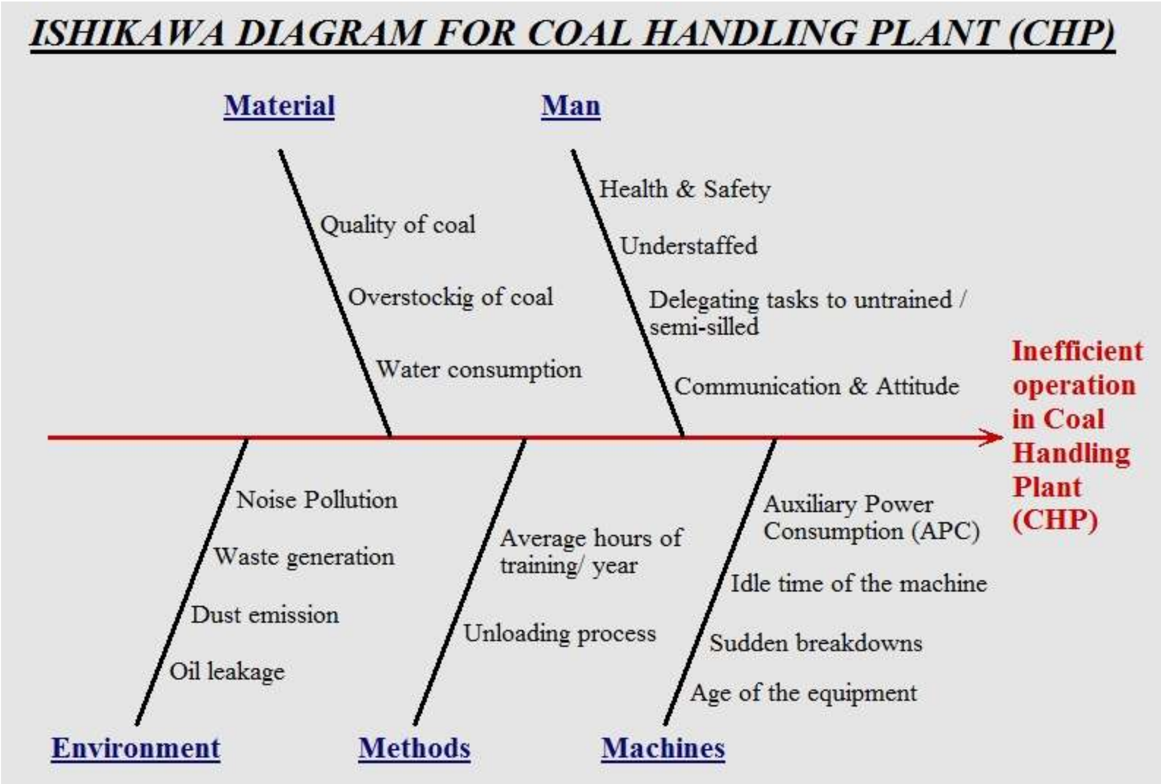

Figure 2Cause and effect (Ishikawa) diagram for Coal Handling Plant in the thermal power plant

3. Results and Analysis

On the basis of Figure 2, possible causes have been determined and a brief explanation have been given in the following sub-section. Some potential suggestions have also been made to tackle these problems.

3.1 Cause and effect diagram

The cause and effect diagram depicted in Figure 2 has been elaborated as follows.

1. Man

(i) *Health & safety of the employees*
The Company is committed to the safety of its employees and takes appropriate measures to avoid any accidents. On a rare event, accidents do happen and the health and safety workers is compromised. The reason could be the level of skill of the employee or some fault in the machine he is working on.

(ii) *Understaffing*

At present, there are approximately 18000 employees in all the stations across the country. This equals to about 0.4 employee per megawatt that is generated. Suffice to say, this is a probable cause for the low staff. Also, to reduce the cost per unit of the generated power, cost cutting is exercised. Therefore, it can be said that the plant is understaffed.

(iii) *Delegating tasks to semi-skilled / untrained employees*

If, an employee is absent, his duty for that day is handed over to someone else. This current employee might not be as skilled or trained as the absent employee. This again could cause an accident or even breakdown of the equipment, which would either be dangerous for the employee or temporary shutdown of the machine.

(iv) Communication & Attitude

The communication between the management and the workmen is an important factor. The attitude and motivation with which the employees work must be kept in mind. A discontent worker may not want to work up to his full potential.

2. Machine

(i) *Auxiliary power consumption (APC):*

One of the main goals of the plant is to minimise the auxiliary power consumption. It refers to the electric power consumed by the plant which is usually 9-10% of the total power produced. Unnecessary lights and other appliances, and machine running when not needed are few of the reasons that contribute to APC. Large vibrations of the equipment are also a factor that could lead to APC.

(ii) Idle time of the machine:

Few of the reasons of a machine's idle time could be the level of skill of the operator, his attitude towards the work or his health. Idle time could also be caused due to less demand from the customers or the stakeholders. The material, that is coal, could also be a contributing factor as in the raw coal might contain some metal pieces which could lead to the breakdown of another machine in the line and consequently, other machines would be idle in that line.

(iii) Breakdown of the machine:

As aforementioned, raw coal might contain metal pieces that can lead to breakdown of the equipment if not detected on time. Also, improper use or untrained operator can cause the machine to breakdown. If preventive maintenance is not regularly employed with the appropriate instructions, there might be frequent breakdowns. Age of the equipment also plays a key role in its performance.

(iv) Age of the equipment:

It is a known fact that frequent breakdowns take place when an equipment is newly installed. Its performance is at its peak in the middle of its life and then breakdowns increase in frequency as it ages.

3. Material

(i) *Quality of coal*

The calorific value (C.V.) of coal is a crucial factor to consider when examining the overall efficiency of the CHP. If the coal received from the source mine is of low C.V., then the amount of coal consumption to produce same electric power is high. This would eventually lead to increase in the cost per unit of the electricity generated.

(ii) Overstocking

Storage of coal over a long period of time deteriorates its quality, that is, its C.V. decreases with time. Self-heating and instant ignition are another issue that are frequently seen when the coal is stored. This also lessen the C.V. of the coal. In rainy season, water cuts through the stored coal and coal drains down through the channels. This lead to wastage of coal.

(iii) Water consumption

Service water is used for cleaning or for cooling purposes. Fire water is stored in the fire line for emergencies like coal ignition. The iron dust reacts with the fire line (which is made of MS), and corrodes it. The line gets holes because of the corrosion which leads to loss of water and therefore higher water consumption.

4. Method

(i) Unloading time

The unloading time of coal onto the feeder depends on the type of wagons received. The BOBRN type wagon is less time consuming while unloading than the BOXN type wagon. Higher the time consumption, more the demurrage is to be paid to the railways.

(ii) Average hours of training per year

The obligatory training time of an employee is recommended to be 7 days per year by the company. Many employees do not feel the need to attend these trainings. This becomes a problem when the employees are expected to keep up with the knowledge of new advancements in the technology related to their own workspace.

5. Environment

(i) Noise Pollution

A source of discomfort to the employees is the noise produced due to machines such as when a bearing in idlers of the belt gets loose or, an idler gets jammed in the belt or in the crusher house where there is a constant noise. Although there are measures taken to minimise the vibration of the machines, there is still fairly a good amount of buzzing going on where the machines are running.

(ii) Waste generation

Waste is generated in the form of e-waste, used stationary items like printer cartridges and worn out components like idlers.

(iii) Dust emission:

This is one of the more serious issue which concerns with the health of the employees working in CHP. There are water spray nozzles and dust extraction fans outfitted at various points from the storage to the bunker. Still there are remnants of dust particles in the air that are harmful.

(iv) Oil leakage:

In equipment like stacker and tippler where usually hydraulic system is used, possibilities of oil leakage are high. In the gearbox, if there is an insufficient amount of oil, the teeth of the gears might break, and an excessive quantity of oil tends to lead to leakage. In the crusher or the belt, there is fluid coupling where if the load is too much, the temperature rises and the plug burst out which then, leads to a leak.

3.2 Recommendations to maximise the productivity of Coal Handling Plant

Some possible suggestions to the corresponding the issues in order to remedy them can be as follows:

1. Man

- Regular check- ups, vaccinations and medications should be administered
- Appropriate measures like wearing protective gear
- Training all the employees by making it compulsory to attend the training session. It must be done at regular intervals
- Rewards and recognition should be frequent so that the employees feel confident & comfortable in sharing their opinions and stay motivated

2. Machine

- Shutting off all the unnecessary appliances and machines.
- Regular preventive maintenance with proper procedure should be administered.
- Equipment should be replaced as it ages past its peak life.

3. Materials

- Overstocking can be avoided by implementing tools like E- Kanban to minimise the inventory, in this case, raw coal as defined by Senthilkumar & Nallusamy (2021).
- Any leakage in the pipelines should mended immediately. The water used should be recycled as much as possible.

4. Method

- The obligatory training should be made mandatory for the employees.

5. Environment

- All the equipment should be checked for unwarranted vibrations. Safety gears should be worn at all times inside the power plant.
- LM practices like 5S/6S, kaizen and lean six sigma can be adopted to minimise the waste.
- Dust exhaustion systems and sprays should be regularly maintained to keep the dust particles to minimum.
- Pipelines, if old, should be replaced to keep the leakage frequency as low as possible.

4. CONCLUSIONS

Quality leads to increased efficiency, as well as enhanced customer satisfaction and loyalty. Utilising cause and effect diagram, some of the major issues have been explored that cause inefficiency in operation at the Coal Handling Plant in the thermal power plant. Subsequently, the appropriate recommendations have been made corresponding to the issues. Following them would ensure the enhancement of quality as well as productivity.

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