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Research Article

Productivity improvement and Waste Reduction in a Cement Refractory

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Abstract

The objective of the research is to study the plants problems in material handling and the workers ergonomics. The detailed study of the plant's processes using operations process chart, flow of material and activity relationship chart has been done. The new plant layout has been designed and compared with the present plant layout. The study showed that the workers were also not been utilized properly. Proper improvements were being suggested in order to improve the working conditions and material handling.

Keywords: *Batch Ball Mill (BBM), Continuous Ball Mill (CBM), Productivity, Nodulizer.*

1. Introduction

Delivering the desired level of performance in minimum time has become a key objective of every competitive organization. In the context of manufacturing, this situation has led to very little flexibility in terms of production schedules, production rate, delivery schedules, quality and other such avenues associated with manufacturing systems. Cycle time in the context of manufacturing can be defined as the total time spent by the part/product in the manufacturing system or the time between the exits of two consecutive parts or it can also be called the time part spends as work in the process [1]. Manufacturing waste is generated during a production process [2]. Waste happens at all stages of the life cycle from design to end-of-life. The purpose of a performative definition of waste prevention is to develop an understanding of the organizational rationale of waste prevention [3].

The following project has its main focus on creating a holistic improvement and a very positive impact on the manufacturing plants working and the life of its employees. Worker health has always been a prime concern for the management and the processes involved in the plant pose an inherent risk to all the labour on the shop floor. This was the prime reason that they were interested in ensuring the maximum safety of their employees. The management was also interested in increasing the productivity of the working as all of their processes were laid down a few decades back and which hadn't been improved since.

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In spite of ergonomics being a discipline with the requisite expertise and methods for analyzing occupational tasks and performance, little qualitative or quantitative information on the equipment, tools and analysis techniques used by practicing ergonomists is available [4]. The use of a participative approach to ergonomics is growing in countries throughout the world. There is an increasing realization in industry that ergonomics is important, not only for worker comfort, safety and health but to improve productivity and quality in manufacturing. Because of increased technological complexity in manufacturing environments, the need for ergonomic design has actually increased. Although many manufacturing tasks can be handled by computerized automated systems, the very existence of these systems makes the performance of the human operator even more critical than previously. The company had always faced the issue of wastage of materials when they were being processed [5]. Hence, they were interested in improvements in the following factors.

1) Worker health
2) Productivity
3) Waste Minimization
4) Worker utilization

2. Problems Identified

The existing process has a laborer who is required to pierce a hanger like instrument in the sack and pull it from a stack of the same onto the ground. Then he has to re-pierce the hanger and drag the sack from the stacks to the trunk, which is about 15 meters from the stack. In this process because of the piercing, the sack

is damaged to a certain extent and hence the lime in it falls on the ground and hence is wasted.

Fig. 1 Carrying the Bags using hanger

When the raw mix is transported from the BBM machine to the Nodulizer, it has to be stored for one time in a WIP stack.

This offers a buffer for the Nodulizer and gives opportunity for quality check. The following raw mix is stored in sacks of about 50 kgs. The sacks are sealed with rubber bands, as they have to be opened in a few hours at the Nodulizer. The following sacks are placed horizontally in the WIP and there are two rows of sacks placed upon each other. When one sack is placed above the other there are multiple times when the rubber bands of the lower sacks burst open. This causes in the raw mix to pour out on the ground and hence get wasted.

Fig. 2 Raw-Mix bags burst due to excess pressure

When being handled the nodules, do tend to fall out of the trolleys at multiple locations. This result in those nodules to be crushed under the workers feet and hence is wasted. This also contributes in the dirtiness of the complete shop floor and requires constant cleaning.

Fig. 3 Nodules being spread on the shop floor

The clinkers are manufactured in the rotary kill. They are thrown out of the trolley because of the inherent force by which they exit the machine. Hence, they fall of the trolley in considerable amounts. The clinkers are the main bottleneck of the plant and hence wastage of this resource is not affordable by the complete process.

Fig. 4 Nodules not being dispensed properly into the trolley

The grinded clinkers are stored in sacks before being processed further. When it has to be used, the sacks are supposed to opened and the powder has to be poured in a bigger container to be transported to the BBM machine. The sacks however are thrown inside the bigger container as they are very heavy. This result in a huge amount of dust to be generated which is extremely hazardous for the workers' health.

3. Plant Analysis

In this study, the refactored cement as production on monthly order basis. The production process, as well as the flow of the operating process, are depicted in Fig. 2. As demonstrated in Tables 1 and 2, the size of the equipment was proportional to the available space. Each day, the refractory would process 60 ton of refactored cement.

The flow of materials, the usability of the plant area, and material handling equipment might be considered as follows, according the original plant layout:

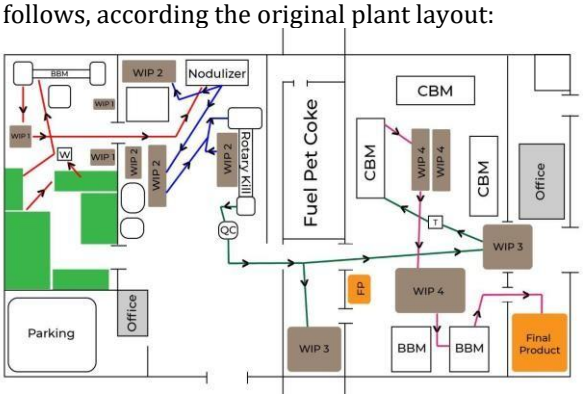

Fig. 5 Raw-Mix bags burst due to excess pressure

A. The Flow of Materials

The processed material travel a long distance that results in a loss of time and energy, at a significant expense as shown in Table 1, 2 such as moving it from

BBM machine to Nodulizer to create nodules for 25m, resulting wasted time and more energy

B. Usability of the Area

- The region was not utilised to its full potential since huge supplies remained in the working area, resulting in a factory that was unused.
- The area near the Nodulizer was much more than the area required for the actual machinery, thereby increasing the travel distance of the material processed on the BBM machine.

C. Material Handling Equipments

Operating and material handling using a mobile crane is a complex task that requires multiple skills. Ergonomics is essential for the movable lifting equipment worker to withstand even in the worst situations. For comfortable operation, the operator's seat shall be made considering the definitions and head control of the human body is therefore essential to hold up to neck & head and to decrease the probability of damage [6]. The raw materials material handling equipment was inadequate, i.e., a shovel was used to fill the raw materials and move it in hand trolleys, and the pathway was not flexible enough due to an untidy arrangement of the items.

D. Storage and WIP of material

- As the manufacturing industry moves away from the mass production paradigm towards the agile manufacturing, the life cycle of products gets shorter while the need for a wide variety of them increases. Keeping large inventories in stock tends to be unattractive in today's markets. The same holds for the unfinished parts throughout the manufacturing system, widely known as work-in-process (WIP), as it represents an already made expense with unknown profitability due to the rapidly changing demand. In a highly changing demand environment, the accumulated inventories are less desirable than ever [7].
- The storage for cement or the raw material was 150 square meters. The working capacity of the plant is 620 tons. At the present time, it could contain 500 tons per month. After the improvement it would have more space to contain the cement or the raw materials
- The WIP material need to be placed properly as it creates hindrance at the time of material movement. This would be addressed in the improvement, by allotting a proper area for it.

4. Process Analysis

According to a review of the production process, it was discovered that the lengthy distance for transferring raw materials could be decreased

1. Batch ball mill:- A ball mill is a type of grinder used to grind and blend bulk material into QDs/Nano size using different sized balls. The working principle is simple; impact and attrition size reduction take place as the ball drops from near the top of a rotating hollow cylindrical shell. The nanostructure size can be varied by varying the number and size of balls, the material used for the balls, the material used for the surface of the cylinder, the rotation speed, and the choice of material to be milled.
2. Nodulizer:- A Nodulizer (or finish mill in North American usage) is the equipment used to grind the hard, nodular clinker from the cement kiln into the fine grey powder that is cement. Most cement is currently ground in ball mills and also vertical roller mills which are more effective than ball mills.
3. Rotary Kill:- the rotary kiln is the core of lime and cement clinker production. In the slightly inclined cylindrical tube, which rotates around its longitudinal axis during the firing process, the lime powder is heated up to 1450 °C and burned into cement clinker. The rotation has both a transport and an air injection effect. The length of such a kiln can be well over 100 meters. In this type of kiln, the limestone is added at the slightly higher end and slowly passes through the kiln due to the rotation.
4. Continuous ball mill: - Heavy duty, continuous type ball mill is with three compartment and screen. Replaceable Liners are fixed inside entire mill. Liners material and shape is selected based on material to be grind. Input material is fed in two primary grinding compartments. Large diameter balls for reduce particle size are laying inside first compartment. Material comes into second compartment for further grinding. Small size Balls are laying inside second compartment. Material comes into third for fine grinding. Smaller size media are laying inside third compartment for fine grinding. Diaphragms may place to regulate material level and control retention time. Material is feed and discharged through hollow trunnion at opposite end. Accessories like air classifier, cyclone, blower, return air circuit or dust collector can also be placed for close loop system. Two tiers fixed on both end of mill, which are rotate on four rollers. Rollers are fixed on support and oil immersed. Mill rotates on four roller and two tiers. Girth gear is fixed on shell, which driven mating gear, gearbox and motor, which are fixed on heavy drive base.

The problems observed in the survey showed that the shop floor needed a number of improvements to get the required efficiency.

The charts developed for the analysis: -

As the manufacturing industry moves away from the mass production paradigm towards the agile manufacturing, the life cycle of products gets shorter while the need for a wide variety of them increases. Keeping large inventories in stock tends to be unattractive in today's markets. The same holds for the unfinished parts throughout the manufacturing system,

widely known as work-in-process (WIP), as it represents an already made expense with unknown profitability due to the rapidly changing demand. In a highly changing demand environment, the accumulated inventories are less desirable than ever the improvement of the quality of the product, and reduction of the production cycle and cost [8].

1. Flow process chart (Overall):- The flow process chart is a graphical and symbolic representation of the activities performed on the work piece during the operation in industrial engineering.
2. It is used when observing a physical process, to record actions as they happen, and thus get an accurate description of the process.
3. It is used when analyzing the steps in a process, to help identify and eliminate waste—thus, it is a tool for efficiency planning.
4. It is used when the process is mostly sequential, containing few decisions
5. Multiple Activity chart: - The multiple activity chart is extremely useful in organizing teams of operatives on mass- production work, as well as on maintenance work when expensive plant cannot be allowed to remain idle longer than is absolutely necessary. It can also be used to determine the number of machines which an operative (or operatives) should be able to look after and assist in identifying bottlenecks.
6. Flow process Chart (clinker Packaging)

5.Inferences

Immense wastage of material due improper handling. The material handling at the refractory was not been done properly as a result a huge amount of material wastage was happening out there.

A. Wastages due to improper handling are given below

- Wastage of Lime: While transport of the lime bags the workers used to pork a hanger into it and drag it to the location, in a powder form it tends to flow out from the bag on the floor causing the wastage of lime.
- Wastage of Raw-Mix: The raw mix were used to be stored on one another stacking horizontally, as these bags were having a zip-locking mechanism they tend to burst when the load of other bags exceeds or if any bag is thrown on one another. This certainly led to a greater amount of raw mix wastage while piling them up.
- Wastage of Nodules: The trolleys made to handle the nodules consists of a huge amount of nodules, which certainly lead to wastage of the nodules by being fallen out from the trolley while transporting them to a certain distance.
- Wastage of Clinkers: While the clinkers were loaded in the machine a certain amount of them fall off the actual pouring area of the machine and are being wasted each time when the machine is loaded. In addition, while processing the clinkers they use to pop out of the machine, which again led to wastage of them.
- Wastage of Grinded Clinkers: Improper handling of the final processed batch of grinded clinkers(powdered), the workers used to pork a hanger into it and drag it to the location, in a powder form it tends to flow out from the bag on the floor causing the wastage of the grinded clinkers.

B. Improper utilization of workers

- We have observed that the workers were not been properly utilized. At the BBM machines, two operators were assigned a same task, which was not necessary at all. When we record our observations on those BBM machines we have found the following results,

	Time activity chart	
	Operator	***Machine***
Idle time	40.5	16
Working time	17.5	42

a. Time measured in minutes.

From this one can easily see that the idle time of the operator working on a single machine is 40.5 minutes in each cycle of the batch, whereas his/her working time is just 17.5 minutes. Thus, we have plotted a Single man Multi- Machine chart to see if a single operate both the machines. Plotting Single man Multi-Machine chart we have reduced their idle time by almost 63%, also an extra operator that can be utilized for other tasks.

	Time activity chart		
	Operator	***Machine 1***	***Machine 2***
Idle time	25.5	7.5	18
Working time	30.5	48.5	38

a. Time measured in minutes.

C. Disregard for worker safety

There was huge amount of dust particles of lime, raw-mix, refactored cement, etc. present in the factory, which would certainly led to respiratory disorders, eye problems, skin disorders, etc. The workers were working without wearing any safety masks, safety eye goggles, earplugs, safety gloves while working in the factory. Many times, it was observed that they were not even wearing safety helmets and safety shoes while working on the machines. Operating the material without any of the safety gear could be dangerous in the end, would certainly result in decrease in performance of the workers and ultimately could lead to death too.

6.Suggestions

A. Tools and trolley system

The wastages of raw materials were mainly because the sacks were being torn while being transported from the storage to workstation. Therefore, we recommended a three-blade tool, which can be used to

grab the sacks and pull them onto a trolley on which it can be transported to the workstation. The sacks will have to be stored on wooden platforms for ease of transfer from stack to trolley. This would reduce the wastage along with improving the working condition of the laborers.

B. Verticle Stacking

The sacks were stored horizontally, which caused its wastage as stated earlier, so for this problem we recommended them to place the sacks vertically instead of horizontally. This surely increased the space requirement but it has eliminated the raw mix wastage at the stage.

C. Plastic Case

There is a wastage of nodules at the storage location; hence, we recommended that there should be industrial plastic laid on the floor stating the location of the nodules. This plastic will be tied to the ends at a slightly elevated height making a funnel like shape and hence containing the nodule stored inside.

D. Hydraulic lift for nodulizer

E. Funnel structure for clinkers

The clinkers are wasted when they exit the rotary kiln as we have seen above, so for this problem we provided a very easy but effective solution of adding a funnel metal plate to the container where the clinkers were being collected. This will reduce the wastage along with being a safety precaution for the workers as these hot clinkers flying around is a very dangerous factor for the laborers.

F. Fitting wheels to trunk

As we saw in the above multiple activity chart and the inference that if the trunk is fitted with wheels it would reduce the cycle time by 57%. This change can bring the labor and work in progress down by a considerable amount, hence reducing costs and time required.

G. Resizing sacks of grinded clinkers powder

The sacks of grinded clinker powder is about 50 kgs. hence it is extremely heavy to lift and impossible to place on the ground gently. Hence, the workers throw the sack on the ground creating a huge amount of dust. To solve this we came up with a solution to reduce the sack capacity to half, this would make it possible to place the bags gently and hence not creating the dust. This will reduce wastage and improve the working conditions

H. Operator reduction on BBM machine

As the multiple activity chart suggests one operator can operate both BBM machines hence increasing productivity and saving on labor costs.

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