Problem Solving and Enhancing the Overall Equipment Effectiveness in Pharmaceutical Industries

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Abstract: **Overall Equipment Effectiveness (OEE) is a method to monitor and improve the efficiency of manufacturing processes. OEE is broken down into three measuring metrics; availability, performance, and quality. The aim of this research is to use these metrics to benchmark the efficiency and effectiveness, and categorize the key productivity losses that occur within a pharmaceutical production plant. During the research, OEE is measured by using different devices and monitored in packaging department of the plant. After that, data were analysed to propose different correction and improvement actions. Results have shown many problems that cause deterioration in OEE, such as using improper production parameters. By adopting some corrective actions, an OEE enhancement has been obtained and losses have been reduced.**

***Key words*— pharmaceutical industries, Problem solving, Overall Equipment Effectiveness.**

I. INTRODUCTION

When manufacturing companies run up against capacity problems today, they immediately look to increase overtime, add shifts, or purchase new equipment. Instead they should look to optimize the performance of their existing machines to increase equipment reliability, minimize changeover times, improve operator performance, and lower overall downtime.

All these investments can be made to increase capacity and will pay greater dividends by allowing a manufacturing plant to spend its valuable time and money on their manufacturing process instead of new machine purchases. There are many other techniques can be utilized to overcome such problems, one of these techniques as discussed below.

Overall Equipment Effectiveness (OEE) can be used for this purpose, because it is an effective tool to benchmark, analyze, and improve production processes. OEE has three factors. First, the Availability which can be measured as the (uptime/ available time). Second, quality can be measured as = (Units produced - defective units) / (Units produced). Third, Performance or productivity which can be defined as (Parts Produced * Ideal Cycle Time) / Operating time (available time). Thus, OEE is (Availability x Performance x Quality). Table 1 shows the areas should be targeted in any OEE study.

Table I: Areas Should Be Targeted In Any OEE Study.

Availability	Performance	Quality
Planned downtime	Speed losses	Production rejects
Breakdowns	Small stops	Rejects on start up

In this research, low OEE results were obtained in a pharmaceutical production plant for the packaging department. Data were collected to figure out the reasons of the low OEE. Then, correction actions were suggested and some of them were applied.

II. LITERATURE REVIEW

OEE has been widely used in production plants to monitor the losses. For example, authors of [1] have used OEE for improvement the production of engine basement. For details in using OEE in production plants, [2] used OEE to improve the production of airbags, [3] implemented the concepts of OEE as a tool for improving the total productive maintenance. For more details about OEE, [4] reviewed this approach and provided a detailed literature review. In pharmaceutical plants, the published work of OEE is limited.

For example, researchers of [5] have used OEE as benchmark for granulation process in pharmaceutical process. Authors of [6] have used OEE to test and compare the greenness of pharmaceutical products. Some studies use one part or two parts of OEE in pharmaceutical industries. For example, performance has been investigated in many studies, such as [7] who focused in performance, [8] and [9] who studied the performance of pharmaceutical firms in specific markets.

III. DATA COLLECTIONS

Data were collected from the XL device; this is very common device in such production plants which is used to display expressive graphics that embeds real-time performance data into a virtually unlimited number of screens - instantly responding to plant floor events as they occur, as in Figure 1a and 1b. This device is accurate, automated, unbiased. Other tool has been used for data collection was the par-code scanner, Figure 1c, which provides a reason codes for stops in the manufacturing line in the form of par code which scanned by the operators to understand why the

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machine stops. The collected data have been saved in a huge table that shows time and date of stop, reason of stop, and the duration. Figure 1d shows a sample data were collected.



Figure 1a: Sample of data exported from XL device.



Figure 1b: XL device screen



Figure 1c: Par code scanner

3/16/2015 08:22	Down	Change roll (pvc\alu)	0:01:37
3/16/2015 08:23	Run	Running	0:03:29
3/16/2015 08:27	Down	Adjustment	0:00:22
3/16/2015 08:27	Run	Running	0:00:02
3/16/2015 08:27	Run	Running	0:01:14
3/16/2015 08:29	Run	Running	0:09:28
3/16/2015 08:38	Down	Feeder Jam	0:00:43
3/16/2015 08:39	Run	Running	0:00:11
3/16/2015 08:39	Down	Feeder Jam	0:00:07
3/16/2015 08:39	Run	Running	0:01:11
3/16/2015 08:40	Down	Feeder Jam	0:00:18
3/16/2015 08:41	Run	Running	0:01:37
3/16/2015 08:42	Down	Feeder Jam	0:00:29

Figure 1d. Sample of saved data

IV. RESULTS AND CAUSE ANALYSIS

According to the collected data, there are many reasons for the stops. First, setup and calibration time of machines it according to the type of medication. Second, carton boxing stop when the medication packets are collected in deformed.

Third, check-weight boxes stops that occur when the medication packs are nor filled probably. Fourth, stops for dry, wet, and full cleaning. Fifth, jams such as feeder, leaflet, and cases jams. Sixth, stops for adjustments when the package size is changed. Seventh, waiting time for quality control and assurance engineer who check the system after each stop. Final, stops to replace materials or change PVC rolls. The first identification and analysis tool is the fishbone diagram. This tool helps us to summarize all types of stops and identify the possible of reasons of each type. Pareto charts are also used to prioritize the causes. These methods of analysis are used because they can provide clear conclusions and lead to better decisions. There are many alternatives that can be used for similar analysis. For example, design of experiments which are more suitable for cases where causes interactions can exist and regression analysis when a predictable relations are required. Fishbone and Pareto charts are used here because they can provide us with the required information, i.e. causes, frequencies, and durations, as will be discussed later. Next sections show the losses and their possible reasons for each part of OEE.

A. Availability

The collected data shows that there are fifteen reasons for availability losses. These are demonstrated in fishbone diagram, Figure 2a. Pareto chart in Figure 2b shows that the "leaflet jam" is the most frequent happening, so this cause will be the focus to be corrected. In the data, there is other important notice which is that the leaflet jam does not need long time to be fixed. So, we should look for other reasons by looking for the total duration of stops. Pareto chart in Figure 2c shows that the feeder jam has the longest time and was the main reason that enforced the machine to stay stop.

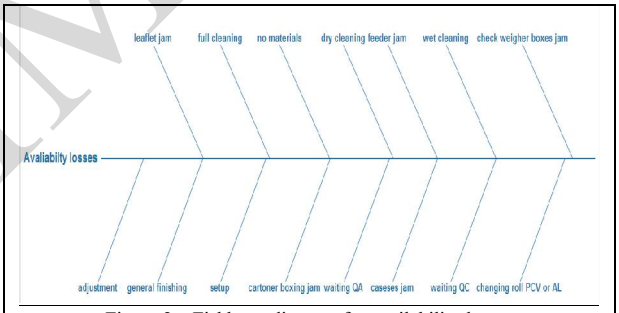


Figure 2a: Fishbone diagram for availability losses

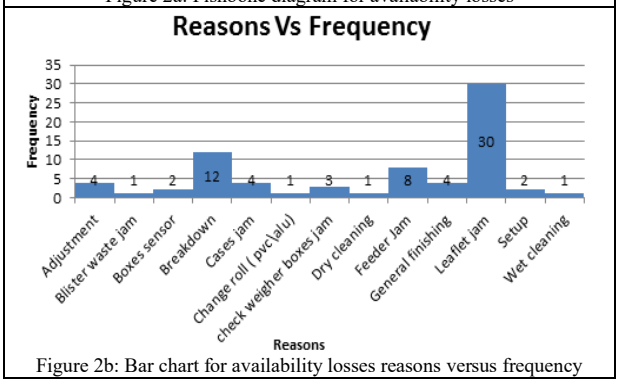


Figure 2b: Bar chart for availability losses reasons versus frequency

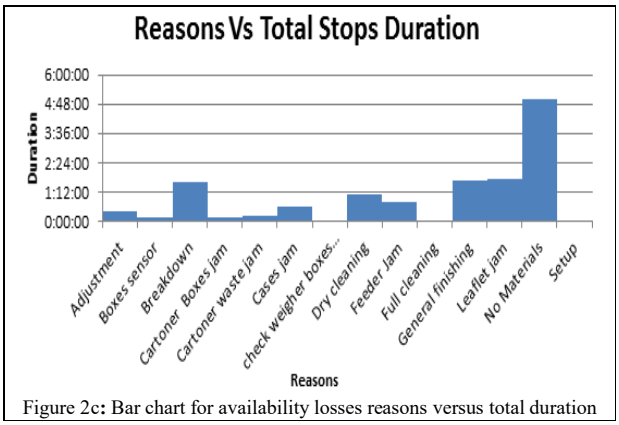


Figure 2c: Bar chart for availability losses reasons versus total duration

B. Performance

Performance is also known as "process rate" which is portion of the OEE Metrics. It represents the speed at which the Work Centre runs as a percentage of its designed speed.

The losses due to wasted performance are also often called *speed losses*. In practice it is often difficult to determine speed losses, and a common approach is to merely assign the remaining unknown losses as speed losses. As seen from Figure 3a and 3b, the factors that effect on the performance losses with no reason identified are considered as a performance losses. Pareto chart for the collected data shows that the number of the "none" reason is the highest one of the rest reasons. That is a result of the workers who do not know why the machine is stop.

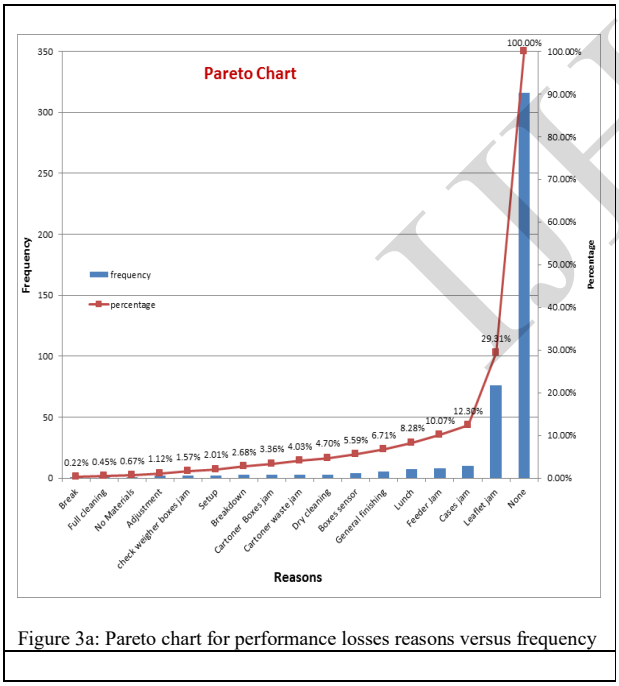


Figure 3a: Pareto chart for performance losses reasons versus frequency

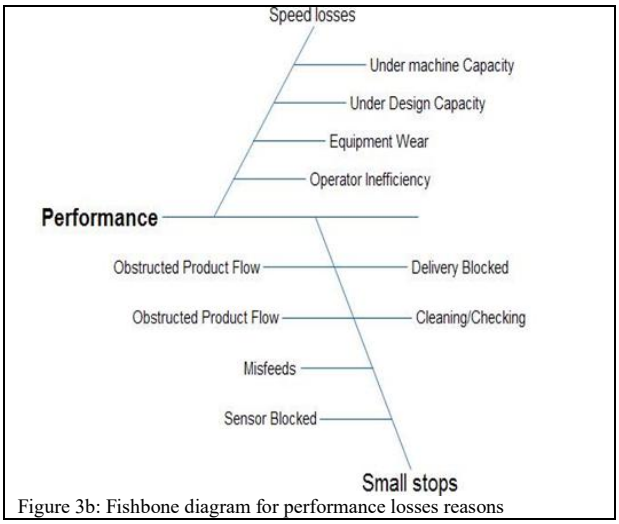


Figure 3b: Fishbone diagram for performance losses reasons

C. Quality

The plant where the study was held take a special care for quality and its products have the highest level of quality. So, we notice that no problems in the quality because once the line had a problem, the whole line will stop and no part will be produce till the line fix and start production again.

V. CORRECTION ACTIONS AND CONCLUSIONS

Performance losses that occurred with non-defined reason are caused because the using of wrong production parameters. There are many production parameters that can be tuned and adjusted to solve many problems, especially the problem with no reasons. Table 2 shows the current value of parameters and the corrected values. The corrected values have been determined through experimental works, expert and skilled workers' opinions, and machine catalogues. After applying the corrected parameters, a noticeable improved performance has been produced. This provides an evidence that our findings are correct.

Table II: Current Value Of Production Parameters And The Corrected Values

Production Parameters	Current Value	Corrected value
Blister width	36mm	36mm
Blister length	72mm	72mm
Blister height	6mm	6mm
Pvc temperature 1	110 C	125 C
Pvc temperature 2	110 C	125 c
Pvc temperature 3	110 C	125 C
Pvc temperature 4	110 C	125 C
Pvc temperature 5	110 C	125 C
First valve pressure	10 bar	5 bar
Second valve pressure	10 bar	5 bar
Third valve pressure	10 bar	5 bar
Fourth valve pressure	10 bar	5 bar
Fifth valve pressure	10 bar	5 bar
Production rate	40 unit/min	70 unit/min

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The problem with defined reason with high frequency and/or duration such as feeder jam which technically tested and found that it is caused by using high pressure in the blister machine valves when comparing it with standard pressure taken from validation department. Other problem such as cases jam which can be eliminated by using better quality cartons. For the leaflet jam, which is very frequent, the main reason for this problem is that the adjusting ruler that are responsible to bend and form the leaflet to its shape in the packet does not work perfectly, and we recommended to change it in the first week of investigation. Finally, breakdown: this problem does not have high frequency but have high duration can be avoided by using good preventive maintenance. Finally, limitations of this study can be summarized as follows. First, data collection needs personnel and devices, which are not always available. Second, improving OEE by implementing the corrective actions are not always applicable, especially when tools and devices replacement is required. Sometimes, organizations might prefer to loose small OEE amount rather than applying costly actions, even these actions are more profitable for long run.

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