

# Analysis of performance and the Overall Equipment Effectiveness (OEE) in a manufacturing company

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**Abstract.** The Overall Equipment Effectiveness (OEE) has become an index of efficiency in terms of the use of machinery, equipment and production resources. It allows entrepreneurs to learn where to look for modest losses, and can be used to eliminate them. The main purpose of determining the OEE is to confront the theoretical use of machinery with the actual one, using a relationship of three main elements: availability, use and quality. The purpose of the paper is to present the experience of the use of the OEE in optimization of production processes in a production company. The most important factor in analyzing the overall effectiveness index of the equipment is choosing the right method for collecting and processing data. The best-known method is filling in of a worksheet by line employees. An analysis was carried out in a production company, determining the SLE production line performance index and using Pareto analysis results, based on data from May 2014 to June 2015. The best-performing component of the OEE is quality, the value of which has not dropped below 95% over the period considered.

## 1 Introduction

An elementary factor in assessing the production line is the efficiency and availability of the machines used. Machines determine the percentage of a fully productive production time, and in the literature these elements are referred to as effectiveness of the use of equipment and resources [1,2]. These factors are identified by a number of activities related to measuring and analyzing the production process in an enterprise, based on which the so-called equipment use index, i.e. the Overall Equipment Effectiveness (OEE) is calculated.

The Overall Equipment Effectiveness (OEE) has become an index of efficiency in terms of the use of machinery, equipment and production resources. It allows entrepreneurs to learn where to look for modest losses, and the information obtained can be used to optimize the production process. The main purpose of determining the OEE is to confront

the theoretical use of machinery with the actual one, using a relationship of three main elements: availability, use and quality. The result of these three elements allows managers to detect minor errors in the use of resources and forms the basis for making rational decisions regarding production, quality control and the need to replace or service the equipment [3].

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It is very important to take care of all OEE elements, because a decrease in one contributes to a decrease in the value of the entire index [3].

The purpose of the paper is to present the experience of the use of the OEE in optimization of production processes in a production company.

## 2 Methodology

The selected production company has five bottling lines for beverages: for PET and glass bottles, and aluminum cans. Each of them produces beverages of different sizes and flavors, which triggers a great need for improved effectiveness. The production plant runs a well-developed production process control system, which facilitates swift and effective detection and elimination of deficits or waste. The lines work in a counter pressure system, using KANBAN cards. This is the method in which the order placed by the customer significantly affects the production process, i.e. activities performed at the end of the value stream report the needs to previous positions. The system's aim is to eliminate unnecessary overproduction and operational inventory [4-7].

For the calculation of the OEE, data on its main components was collected, i.e. availability, use and quality of production resources. To this end, information was obtained on:

- a) the manufactured volume, i.e. the quantity of finished products (pcs),
- b) downtime, i.e. total time spent on redundant operations and processes such as failures, washing, retooling and other operations related to downtime (h),
- c) operating time, i.e. the total duration of the production process (h),
- d) defective products, i.e. physically damaged (bottles) or qualitatively damaged (e.g. mold germs) (pcs),
- e) daily working time, 24-hour working time (3 shifts).

The most important factor in analyzing the overall effectiveness index of the equipment is choosing the right method for collecting and processing data. The best-known method is filling in of a worksheet by line employees. It consists in recording properly defined deficiencies with an eight-hour operation mode, then calculating and analyzing them in the form of charts [1]. This method, although the easiest, has many disadvantages, e.g. reliability of production or the frequency of value processing. The second, more accurate method is filling digital sheets using appropriate software, e.g. OEE SPC, MES (Manufacturing Execution System)/SCADA cards. This involves filling out digital sheets, and then calculating and generating reports and results as printouts, or saving them on a computer [1].

## 3 Result

To assess the efficiency of the production line, two indexes describing it must be carefully analyzed. The first is the performance of the SLE production line, which was calculated for the bottleneck. For this purpose, the pre-prepared Pareto analysis was helpful. The time taken into account was the period from May 2014 to June 2015. Based on the available

data, the SLE index was calculated. As a result, the following results were obtained (Table 1).

**Table 1.** SLE index for the production line (May 2014-June 2015)

YEAR		2014							
Month	May 14	June 14	July 14	August 14	September 14	October 14	November 14	December 14	
Total	62.77	63.50	62.65	65.02	63.87	64.38	65.93	63.25	
Goal	62.50	62.50	62.50	62.50	61.00	61.00	61.00	61.00	
YEAR		2015							
Month	January 15	February 15	March 15	April 15	May 15	June 15			
Total	66.89	64.49	66.11	68.26	68.49	69.87			
Goal	65.00	65.00	65.00	65.00	66.00	67.00			

Table 1 summarizes the SLE results for the glass bottle production line, taking into account the assumed monthly target based on demand and sales forecasts. At this point, it should be emphasized that the carbonated drinks market in Poland is strictly seasonal. Therefore, the highest demand, and thus the highest production was observed in the spring and summer months, while the lowest production characterizes the cold seasons of the year. The winter season is also intended for production stops for repair and servicing. Therefore, the level of performance at this time is lower [8-11].

In the next step, the effectiveness of the use of machines and devices on the production line in question was analyzed using the OEE index.

**Table 2.** Data necessary to calculate the OEE

	Volume produced (pcs)	Operating time (h)	Operational standstill time (h)	Retooling time (h)	Failures (h)	Washing (h)	Other (h)	Deficiencies (pcs)	Daily working time (h)
May 14	354,153	234.52	3.25	25.33	5.83	8.62	11.06	11,680	24.00
June 14	368,391	245.70	7.25	29.27	9.87	7.67	3.18	12,789	24.00
July 14	370,232	249.20	8.77	25.08	5.88	6.75	7.22	10,090	24.00
August 14	307,909	203.65	7.25	20.25	7.28	6.53	10.03	11,789	24.00

September 14	306,490	203.81	10.42	23.50	10.93	8.23	5.13	9,978	24.00
October 14	301,729	202.77	9.57	23.60	8.32	7.56	4.89	7,756	24.00
November 14	291,390	199.87	5.78	24.77	6.54	5.34	3.65	10,089	24.00
December 14	289,882	187.99	2.16	23.44	6.77	5.06	3.22	12,456	24.00
January 15	269,039	178.14	3.72	24.53	6.03	4.93	5.72	13,564	24.00
February 15	290,732	193.97	2.97	23.55	3.50	4.57	9.80	10,987	24.00
March 15	137,828	91.86	2.73	22.70	1.28	5.25	4.07	6,784	24.00
April 15	252,782	167.64	3.93	26.88	1.92	3.93	6.13	11,543	24.00
May 15	325,405	227.33	3.45	24.67	3.24	6.57	10.15	8,834	24.00
June 15	356,454	234.48	8.24	25.98	2.33	7.22	9.36	12,555	24.00

Table 2 assembles the data necessary to calculate the efficiency index for using machines on the production line in question. Data collection consisted in reporting real information related to the analysis by machine operators. As can be seen, the OEE is mainly based on data on the largest losses on the production line. It was found that retooling operations take the most time, as compared to other non-production activities. For the analysis of the OEE, 24-hour work time in the four-brigade system was taken into account. Based on the above data (Table 2), calculations were made and the results obtained are presented below (Table 3).

**Table 3.** OEE index and its components

	Downtime (h)	Availability (%)	Utilization (%)	Quality (%)	OEE
May 14	54.09	0.77	0.88	0.97	65.5%
June 14	57.23	0.77	0.87	0.97	64.4%
July 14	53.70	0.78	0.87	0.97	66.4%
August 14	51.35	0.75	0.83	0.96	59.7%
September 14	58.22	0.71	0.87	0.97	60.1%
October 14	53.94	0.73	0.85	0.97	60.8%
November 14	46.08	0.77	0.87	0.97	64.6%
December 14	40.65	0.78	0.89	0.96	66.8%
January 15	44.93	0.75	0.88	0.95	62.5%
February 15	44.38	0.77	0.88	0.96	65.3%
March 15	36.03	0.61	0.86	0.95	49.7%
April 15	42.80	0.74	0.85	0.95	60.4%
May 15	48.08	0.79	0.84	0.97	64.4%
June 15	53.13	0.77	0.87	0.96	64.9%

It should be emphasized that the OEE is a measure of the efficiency of production line resources, i.e. an index of the efficiency of machines and devices, while maintaining the appropriate quality of products [3]. The value of the OEE index for the enterprise in question is closely related to the effects of the SMED project, which was implemented in the enterprise's production line. The higher the OEE index, the lower the resource efficiency and effectiveness. To take a closer look at this relationship, the OEE index was analyzed after the SMED project was carried out on the production line. The set of data needed to calculate the OEE was assembled in Table 4.

**Table 4.** Data on production line resources (July 2015-January 2016)

	Volume produced (pcs)	Operating time (h)	Operational standstill time (h)	Retooling time (h)	Failures (h)	Washing (h)	Other (h)	Deficiencies (pcs)	Daily working time (h)
July 15	376,432	256.0	7.2	25.2	3.4	5.6	8.2	11,355	24
August 15	347,822	235.8	4.2	24.3	2.8	5.4	7.2	10,900	24
September 15	310,355	205.2	5.4	23.4	1.5	7.1	9.4	9,109	24
October 15	305,202	201.3	2.1	22.8	2.6	6.4	4.5	6,212	24
November 15	289,340	194.2	2.4	23.8	3.2	4.2	5.1	6,465	24
December 15	255,990	184.0	3.2	22.4	1.9	3.9	7.4	9,876	24
January 16	225,478	165.4	2.0	22.6	3.0	3.8	6.4	5,765	24

Table 4 summarizes the most important information necessary to calculate the OEE for the period in question. The data were collected thanks to a group of dedicated production line operators, involved in the project during their shifts. The material for analysis was recorded in reports and then entered into the computer system (MS Excel).

## 4 Summary

The tests carried out, and the results obtained, present the character and individual indexes associated with the use of production machinery and equipment in the examined enterprise at bottling into PETs, glass bottles and cans.

Based on the calculations, it was found that the best-performing component of the OEE is quality, the value of which has not dropped below 95% over the period considered. This turned out to be a great result for the company, considering the fact that the plant strives for the best quality of production.

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