



# IMPROVE PRODUCTION EFFICIENCY BY USING OVERALL EQUIPMENT EFFECTIVENESS (CASE STUDY – ONE OF EGYPTIAN FOLDING CARTON PACKAGING PRESSES)

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## ABSTRACT

*Most of Egyptian packaging companies have continual problems for balancing their production capacity with the ever changing sales and customer demands. They have been forced to accommodate to the customers' needs through increased overtime. This problem has created breaks in the manufacturing process of the customers' orders as well which cause late deliveries and partial shipments.*

*The purpose of this paper is to review one of Egyptian folding carton packaging companies current production capacity restrictions (case study) and compare it to their sales and customers' demands. Reviewing the data will assist in configuring a long-term solution option. This paper will:*

- 1. Evaluate the current production Overall Equipment Effectiveness (OEE) of one sheet-fed offset printing machine.*
- 2. Analyze the three main factors according to six big losses.*

*As more important results, it has been found lack of preventive maintenance management, causing many stops breakdowns, low speed machinery. Also, takes long time of setup and make-ready of equipments, due to shortage of skilled operators. Furthermore, rejected of production resulting from the non-use of quality methods effectively.*

*The researcher recommends to measure continuously overall equipment effectiveness to be able eliminate all of the big losses and continue to improve the printing productivity.*

**Keywords:** *Overall equipment effectiveness (OEE), availability, performance, quality factor, sheet fed litho-offset printing machine, folding carton packaging.*

## I. INTRODUCTION

Recently, more of Egyptian packaging companies tend to new customers requirements and in particular the direction of some of them for outside export as medicines, food and multi-national Companies, which depend on used packing world-class quality .

According to this demand, they need to increase their possibility of improving productive efficiency requirement necessary for them, which means the interest presses raise overall equipment effectiveness to meet them .

In our case study of one of the Egyptian packaging printing companies had not applied scientific method to improve productivity, consequently could not measure it, and as a result it cannot be controlled. Consequently, there are many problems which can be summarized in the following:



- (1) delay delivery of the job orders for customers dates,
- (2) complaint of inconsistency in quality,
- (3) increase of rejected goods,
- (4) low printing machine performance in spite of its modernity.

From these standpoints, this research study to apply Overall Equipment Effectiveness (OEE) as tool to measure and analysis of big losses to can overcome it and to improve productive efficiency level.

### 1.1 RESEARCH PROBLEM:

The research problem can be found in the following question: Can be applied overall equipment effectiveness on one of Egyptian packaging presses (case study) as measurement tool to analysis of losses to improve production efficiency?

### 1.2 RESEARCH AIMS:

1. Analysis the causes of decline in overall equipment effectiveness of the printing machines and how to improve them.
2. Analysis of six big losses that affect overall equipment effectiveness of packaging production.

### 1.3 RESEARCH METHODOLOGY:

The research methodology clarifies the steps and procedures used to analyze overall sheet fed offset printing machine effectiveness in one of Egyptian printing companies. The data collected is then used to identifying production losses used to identify process improvement methodologies.

### 1.4 STUDY DELIMITATIONS:

1. Spatial border - a major Egyptian packaging company to produce folding carton boxes
2. Temporal border - 2014
3. Substantive border - it is limited to the study of research in the case study of printing facility to calculate overall equipment effectiveness in printing department.

## 2. LITERATURE REVIEW

This part will discuss the definition of production efficiency and motives of overall equipment effectiveness, analyze its relationship with the six big productivity losses related to processes, and the definition of the world class of an overall equipment effectiveness <sup>(1)</sup>.

### 2.1 MAIN CONCEPT OF PRODUCTION EFFICIENCY

An operational state whereby a company cannot increase output of a specific goods without additional costs <sup>(2)</sup>.

it is ratio of actual output with an expected standard. Production efficiency means optimal use of factors of production, labor, material and financial resources and data available, to obtain most benefit from them. it can be expressed in the following equation <sup>(3)</sup>.

$$\text{Production efficiency} = (\text{Actual output} / \text{standard output}) \times 100$$

Consequently, production efficiency can be raised by using one of following ways:

- Increasing finished products ratio, while reducing inputs value used.
- Increase finished products ratio, with Survival of fixed inputs value.
- Constancy of finished products value, while reduce resources used <sup>(4)</sup>.



## 2.2 FACTORS TO IMPROVE PRODUCTIVITY:

There are several factors that affect productivity in any printing-houses, including external factors, which cannot be controlled, and interior factors, which is possible to control them:

### 2.2.1 INTERIOR FACTORS:

Regarding to Internal factors, which can be controlled but by varying degrees of difficulties, thus it can be classified into two types:

2.2.1.a. Factors that are difficult to alter them, because they require huge potential to change, such as; used printing technology, the type of equipments, the quality of raw materials.

2.2.1.b. Factors that are easy to change them: availability, performance rate, quality level, which will be searched through this paper.

### 2.2.2. EXTERNAL FACTORS

These factors that cannot be controlled in any way because it is outside its powers and capabilities, and These factors include:

2.2.2.a. Government policies

2.2.2.b. Political and social regulations

2.2.2.c. Business environment

2.2.2.d. Availability of funding

2.2.2.e. Availability of energy, water, transportation, telecommunications and raw materials.

Which directly affect the productivity value. And the administration should understand these factors and take it into account when planning and implementing production programs <sup>(5)</sup>.

## 2.3. CONCEPT OF OVERALL EQUIPMENT EFFECTIVENESS

Overall Equipment Effectiveness (OEE) is a total measure of performance that relates the availability of the process to the productivity and quality.

By implementing an overall equipment effectiveness (OEE) scale that can measure and analyze OEE the printing company can improve machine performance, operating procedures, and maintenance processes <sup>(6)</sup>.

### 2.3.1. OEE CALCULATION

OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products <sup>(6,7)</sup>.

#### 2.3.1.a. AVAILABILITY

Availability is a proportion of time that a machine is available for production, it takes into account Down Time Loss, and is calculated as:

$$\text{Availability} = \frac{\text{Actual time}}{\text{Available time}} \times 100\%$$

Where:-

Available Time = Total Available Time –Planned Downtime

Actual Time = Available Time – Unplanned Downtime

Figure (1) is shown the main big losses of unplanned downtime.



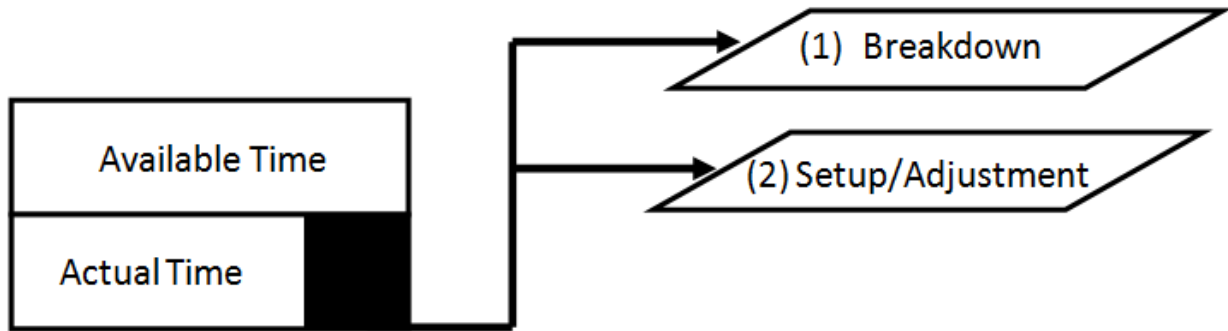


Figure (1): Main two big losses of availability metric.

### 2.3.1.b. PERFORMANCE

Performance means how efficiently the printing line is actually running. It takes into consideration only the running time of the printing machine, not all labor hours.

Performance takes into account Speed Loss, and is calculated as:

$$\text{Performance} = \frac{\text{Actual Production}}{\text{Expected Production}} \times 100\%$$

Figure (2) is shown the main two big losses, which reduce actual production than expected production for same actual time.

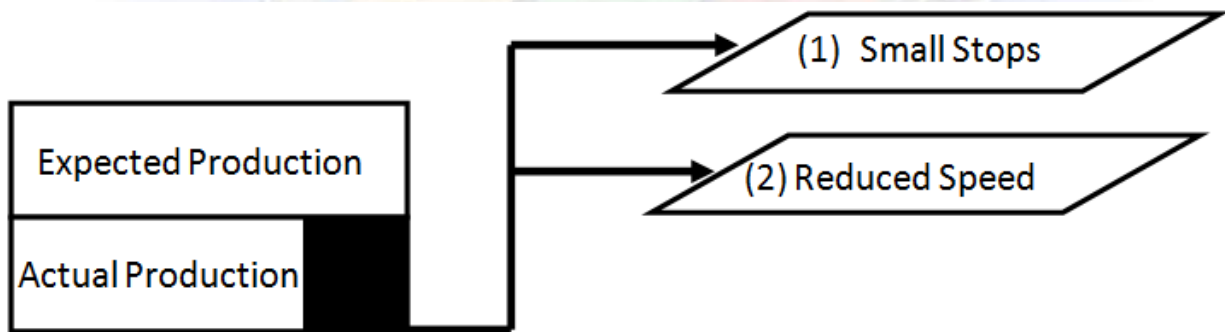


Figure (2): Main two big losses of performance metric.

### 2.3.1.c. QUALITY

Quality is the easiest to define at this step as either good or bad for calculating purposes, it takes into account Quality Loss, and is calculated as:

$$\text{QUALITY} = \frac{\text{Quality Production}}{\text{Actual Production}} \times 100\%$$

Where:-

Actual Production = Quantity of product + bad parts



Quality Production = Quantity of products – bad parts

Figure (3) is shown the main two big losses of quality ratio reduction.

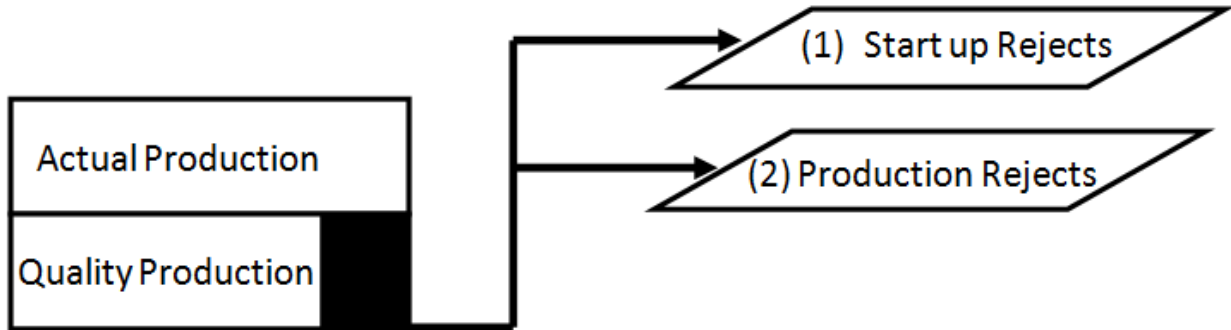


Figure (3): Main two big losses of quality metric.

OEE is calculated as the product of its three contributing factors:

$$OEE = \text{Availability} \times \text{Performance} \times \text{Quality}$$

#### 2.4. WORLD CLASS OEE

This type of calculation makes OEE a severe test. For example, if all three contributing factors are 90.0%, the OEE would be 72.9%. In practice, the generally accepted World-Class goals for each factor are quite different from each other, as is shown in the table (1) <sup>(7)</sup>.

Table (1): World Class OEE

OEE Factor	World Class (%)
Availability	90
Performance	95
Quality	99.9
OEE	85

### 3. CASE STUDY ANALYSIS

The following section discusses the case study company, one of Egyptian packaging and printing companies to producing folding carton boxes. Within this section the manufacturing processes and major product lines are considered. The application of OEE within this environment is then presented.

It was founded in 1960. Today it can be considered as one of the twenty biggest producers in the Egyptian packaging and printing companies area. The company employed approximately 500 persons in 2014. It has ISO 14001 environment, ISO 9001 quality and OHAS 18001 standards.

#### 3.1. DATA COLLECTION PROCEDURE

Firstly, the company's reports of the annual data in each of the seven company departments was gathered, human resource, quality, production, maintenance, store, and planning departments.

The collected data has provided more information than was needed for this paper. The human resource data reports number of workers in the company and also planned breakdown as week end and holiday days per year, also the level of worker's skills for our pilot object, quality control department provided quantities of good product as well as the exact amount of reported waste per production center.

The production summary report also provided the average run standard which is what the

production center achieved in production. Also, maintenance department reports log book of our pilot printing machine. Production planning reports statistically of all unplanned breakdown types and causes of it, also historical rates used in estimating the production time whether it's the setup or run time for scheduling. The reports also provided the actual printing machine output or actual time.



### 3.2. EVALUATE THE CURRENT PRODUCTION OVERALL EQUIPMENT EFFECTIVENESS (OEE) OF ONE SHEET-FED OFFSET PRINTING MACHINE.

First, look at availability which was the company's overall total available work hours.

This was calculated as 296 workdays multiplied by 24 work hours for two shifts. This company only operates manufacturing on a six-day workweek. Rest days can be considered as 52 week-end days and 17 days as governmental holidays. Every shift has planned breakdown as shown in table (2).

Table (2) Planned breakdown/shift

Type of planned breakdown	Time (minute)/ shift
Periodically pre-start production meeting	30
Preventative maintenance	30
Lunch break	90
Sum	150

According to previous data, available time for one year can be calculated as following :

Available time for one shift = 720 min. (60 min. x 12 h.) – 150 min (planned breakdown) = 570 min/ shift.

Available time for one day = 2 shifts = 570 x 2 = 1140 min.

Available time for one year = 296 days/year x 1140 min. = 337,440 min/year. = 5624 h./year

According company's reports, it can be calculated all unplanned breakdown time as 1184 h.

According to the production reports, it has calculated the following data:

Actual sheet/hour = 10,000 sheet/h.

Actual production = 39,368,000

According to quality control reports, it has gathered the following data;

Good production = 31,494,400

According to previous data OEE, for pilot litho-offset printing machine can be calculated as shown in table (3).



Table (3) OEE Calculations for litho-offset printing machine

	Data	Calculated
Available Time (hours)	5624	
Unplanned downtime (hours)	1184	
Actual time (hours)		4440
Availability = $\frac{\text{Actual time}}{\text{Available time}} \times 100\%$		
<b>Availability Calculations</b>	(4440/5624)x100= 78.9%	
Actual production	39,368,000	
Actual machine speed/hours	10,000	
Operating time	4440	
Expected production		44,400,000
Performance = $\frac{\text{Actual Production}}{\text{Expected Production}} \times 100\%$		
<b>Performance Calculations</b>	(39,368,000/44,400,000)x100= 88.7%	
Actual production	39,368,000	
Rejects		7,873,600
Good production	31,494,400	
QUALITY = $\frac{\text{Quality Production}}{\text{Actual Production}} \times 100\%$		
<b>Quality Calculations</b>	(31,494,400/39,368,000)x100 = 80%	
OEE = Availability x Performance x Quality		
<b>OEE Calculations</b>	78.9% x 88.7% x 80% = 56%	

it can be indicated that OEE scale of this machine is lower than the world class OEE as shown in table (1). According to that, we can analyze the main opportunity causes and their remedies as in the following;

### 3.2.1. AVAILABILITY REDUCTION

There are many reasons, which were gathered from production, human resources, and maintenance reports, as shown in figure (4) according to total time losses.

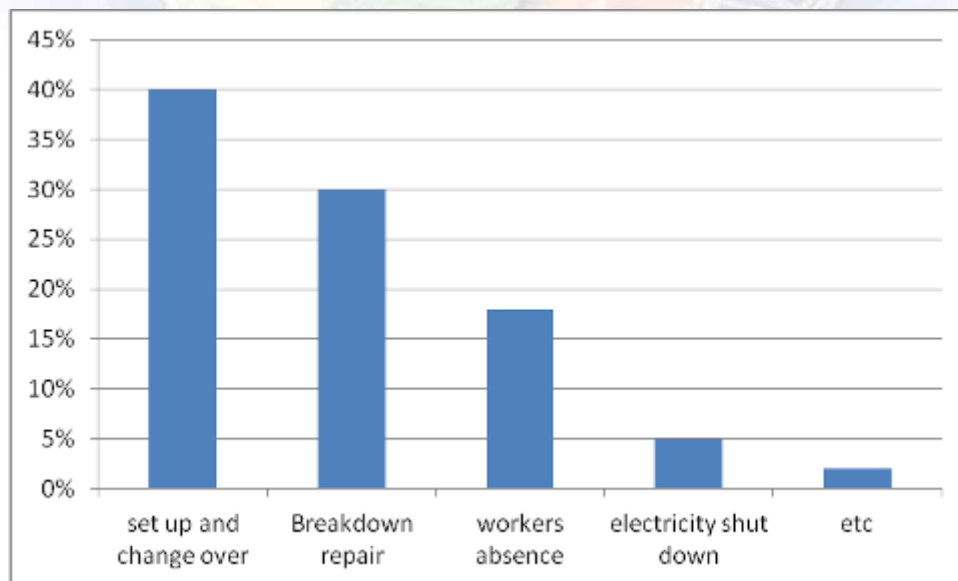


Figure (4): Percentage value of availability losses at case study implementation

Table (4) investigates the possibility of using Pareto Law to identify the causes according to their opportunities and how they can be solved <sup>(8)</sup>.





Table (4): Opportunities of availability losses and their remedies

	<b>Opportunity</b>	<b>Remedy</b>
1	Set up and change over	<u>Human Resource Department</u> Periodically, training courses should be performed to develop practical skills of operators. <u>Production planning department</u> Responsible for production scheduling and loading, which it should depend on scientific methods. <u>Production Department</u> To insure that materials are enough to complete job order.
2	Break down repair	<u>Maintenance Department</u> Responsible for preventative maintenance according to time plan. To activate the implementation predictive Maintenance.
3	Workers Absence	<u>Human Resource Department</u> Adopt motivation policies.
4	Electricity shut down	<u>Cooperate between Purchase and maintenance departments</u> Buy generator _

### 3.2.2. PERFORMANCE REDUCTION

There are many reasons, which were gathered from production, quality control, production planning, store, and maintenance reports, as shown in figure (5) according to total losses consumption.

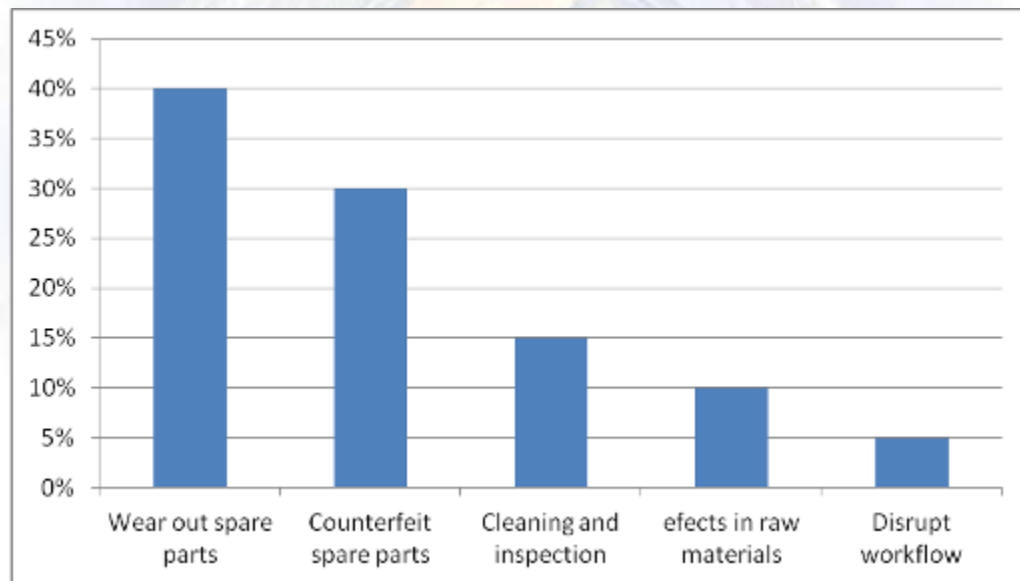


Figure (5): Percentage value of performance losses at case study implementation

Table (5) investigates the possibility of using Pareto Law to identify the causes according to their opportunities and how they can be solved <sup>(8)</sup>.





Table (5): Opportunities of performance losses and their remedies

	<b>Opportunity</b>	<b>Remedy</b>
1	Wear out spare parts	<u>Maintenance Department</u> To activate the implementation predictive Maintenance. Availability of spare parts stores.
2	Counterfeit spare parts	<u>Maintenance Department</u> Approved to purchase and utilize original spare parts only.
3	Cleaning and inspection	<u>Maintenance Department</u> Responsible for preventative maintenance according to time plan. To activate the implementation predictive Maintenance.
4	Defects of raw materials	<u>Quality Control Department</u> Technical inspection on incoming raw materials. Conduct technical inspections during operations on an continuing basis.
		<u>Store Department</u> Responsible for the availability of material storage according to technical and safety properties and appropriate handling.
5	Disrupt workflow	<u>Production Department</u> Awareness to the issuance of digital proofs (Prepress Section). Implementation of color management systems.
		<u>Production Planning Department</u> Implementation of job orders only after the client's approval of digital proofs.

### 3.2.3. QUALITY REDUCTION

There are many reasons, which were gathered from production, quality control, production planning, store, and maintenance reports, as shown in figure (6) according to total losses consumption.

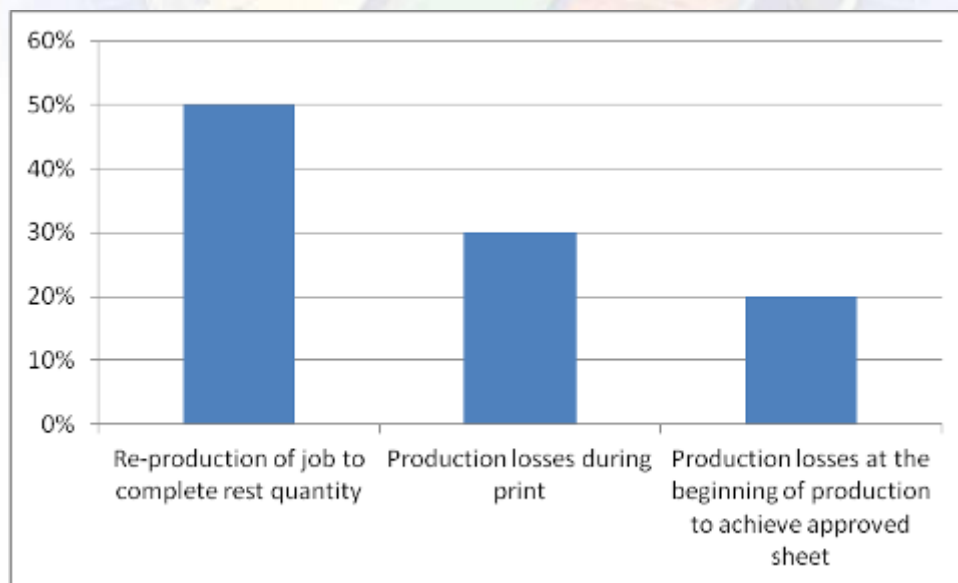


Figure (6): Percentage value of quality losses at case study implementation

Table (6) investigates the possibility of using Pareto Law to identify the causes according to their opportunities and how they can be solved <sup>(8)</sup>.



Table (6): Opportunities of quality losses and their remedies

	<b>Opportunity</b>	<b>Remedy</b>
1	Re-production of job to complete rest quantity	<p><u>Production Planning Department</u>                      Identification of production quantities, taking into account the actual wastage rate through the regular observing and analysis of production processes.</p> <p><u>Quality Department</u>                      Quality control and analysis to identify the wastage rates for printing processes.</p>
2	Production losses during print	<p><u>Quality Department</u>                      Systematic inspection for printed sheets during printing process.                      Regular examination for dampening solution specifications.                      Activating the role of measurement devices to conduct periodic checks on production.</p> <p><u>Human Resource Department</u>                      Periodically, it should be performed training courses to develop practical skills of operators.</p>
3	Production losses at the beginning of production to achieve approved sheet	<p><u>Quality Department</u>                      Implementation of color management systems.                      Technical inspection on incoming raw materials.                      Conduct technical inspections during operations on an continuing basis.</p> <p><u>Human Resource Department</u>                      Periodically, training courses should be performed to develop practical skills of operators.</p>

### 3.3. ANALYSIS OF THREE MAIN FACTORS ACCORDING TO SIX BIG LOSSES

The 6 Big Losses are the major causes of shortfall in manufacturing and as such are crucial to Overall Equipment Effectiveness OEE. According to previous results of three main factors associated with the calculation of overall equipment effectiveness, It can be analyzed according to six big losses, as shown in the table (7).

Table (7): Relationship between six big losses category and OEE

<b>Six Big Loss Category</b>	<b>OEE Loss Category</b>	<b>Causes</b>
Breakdowns	Availability	Spare part Failures Unplanned Maintenance Electricity shut down
Setup and Adjustments		Setup and change over Break down repair Operator Shortages
Small Stops	Performance	Obstructed Product Flow Cleaning and inspection Defects of raw materials.
Reduced Speed		Wear out spare parts. Counterfeit spare parts. Operator Inefficiency.
Startup Rejects	Quality	Production waste at the beginning of production to achieve approved sheet.
Production Rejects		Re-production of job to complete rest quantity. Production losses during print.



#### 4. CONCLUSION

According to previous results, it can be obtained three main important items.

##### 4.1. DIGITAL SCALE TO MEASURE MACHINE EFFECTIVENESS

We can compare between the current OEE and the world class OEE, which can be shown in table (8).

Table (8): Comparison between world class OEE and current calculation

Factor	World Class	Current Calculation
Availability	90%	78.9%
Performance	95%	88.7%
Quality	99.9%	80%
OEE	85%	56%

By analyzing table (8), it can be indicated that the priorities their factors affecting the measure of the overall equipment effectiveness accordingly to:

- 1) Performance
- 2) availability,
- 3) Quality

To improve current OEE, it should start by solving the main losses of performance rate as a first step. After that, the availability problems and final quality losses can be solved.

##### 4.2. IDENTIFY DIFFERENT DEPARTMENTS, WHICH INFLUENCE ON OVERALL EQUIPMENT EFFECTIVENESS

To identify the different departments, which influence on decrease OEE, it should be considered through main causes, and it can be identified as shown in figure(7).

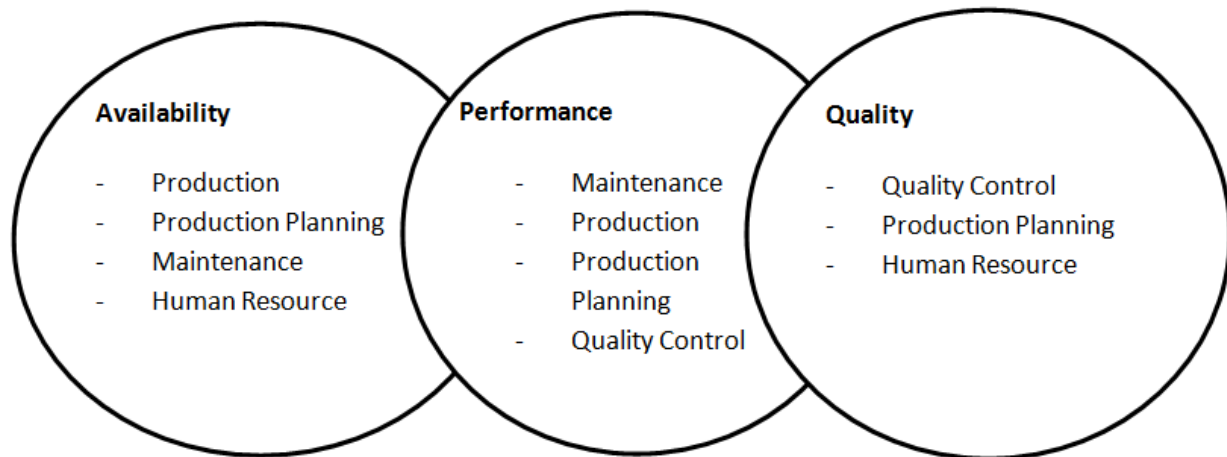


Figure (7) Responsibility of Company's Departments on OEE factors



#### 4.3. IDENTIFY OPPORTUNITIES THAT WILL INCREASE THE EFFICIENCY OF EQUIPMENT

To identify opportunities that will increase the efficiency of equipment, all departments should achieve scientific management methods to improve production efficiency according to actual company situation, as mentioned in table (9).

Table (9): Identification of opportunities to increase the efficiency of equipment

Department	Opportunities
Maintenance	Responsible for preventative maintenance system
	Activate the implementation predictive maintenance system
	Approved to purchase and utilize spare parts
	Availability of spare parts stores
Human Resources	Periodically, it should be performed training courses to develop practical skills of operators.
	Adopt motivation policies.
Quality Control	Technical inspection on incoming raw materials.
	Conduct technical inspections during operations on an continuing basis.
	Implementation of color management systems.
	Systematic inspection for printed sheets during printing process.
	Regular examination for dampening solution specifications.
	Activating the role of measurement devices to conduct periodic checks on production.
	Responsible for availability material storage according to technical and safety properties and appropriate handling.
Production Planning	Implementation of job orders only after the client's approval of digital proofs.
	Identification of production quantities, taking into account the actual wastage rate through the regular observing and analysis of production processes.
	Responsible for production scheduling and loading, which it should depend on scientific methods.
Production	To insure that materials are enough to complete job order.
	Awareness to the issuance of digital proofs (Prepress Section).

#### 5. RECOMMENDATION

According to the results and conclusions of this paper, overall equipment effectiveness should be measured as a continuously method to improve production efficiency and analysis results according to six big losses, which can be solved by the departments of maintenance, production, quality control, production planning, human resources.

At this moment, the possibility of continuous improvement of productive efficiency can be obtained.





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