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Analysis of Performance by Overall Equipment Effectiveness of the CNC Cutting Section of a Shipyard

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ABSTRACT

Shipbuilding industry is considered to be a thrust sector in the economy of Bangladesh. In the shipbuilding process, CNC cutting is used to cut steel plates according to the ship design. The objective of this thesis is to measure the performance of the CNC section. To do this, Overall Equipment Effectiveness (OEE) is selected; a tool of Lean Manufacturing widely used to measure the efficiency of a manufacturing plant in terms of *availability*, *performance* and *quality* and also identify the major productivity losses. Data were collected from the CNC shop to calculate the OEE percentage. The amount of three OEE losses i.e. downtime, speed loss and quality loss was measured and the liable factors behind these losses were identified. It is found that the Overall Equipment Effectiveness of CNC cutting section of Western Marine Shipyard Ltd. is 35.01%. Finally, some recommendations were given to improve efficiency of the CNC section by eliminating these factors.

Keywords: *Shipbuilding, OEE, CNC, Productivity Loss, Performance*

1. INTRODUCTION

Bangladesh has been since 2005 building and exporting ships to owners from Denmark, Mozambique, Germany, Netherlands and Finland. Ours is a traditionally sea fairing country and there are hundreds shipyards here of which 124 have been reported to be registered with the Department of Shipping (DOS) [1]. Among these there are only few which maintain global standard. Market research indicates that there is a huge gap in supply and demand in world vessel market. Specially, as the world's leading shipbuilders in China and South Korea increasingly focus on large vessels such as ever-bigger container carriers and specialized ships such as transporters of liquefied natural gas, it is a great chance to attract more buyers of small vessels and explore a market worth US$ 200bn [2]. But elevating the production system to a global standard in terms of quality, productivity etc. is prerequisite to grab market opportunity. In this research, we analyzed the performance of the CNC (Computer Numerical Control) section of Western Marine Shipyard Ltd. by Overall Equipment Effectiveness to identify the major category of losses exist here and to specify the room for improvement.

2. METHODOLOGY

This research is a case study in which we followed a systemic way to reach the solution of research problems. After a few primary visits an idea is generated and literature is studied according to it. Then data is collected and analyzed from the field according to the literature. Finally, the result is obtained. The methodology we followed can be represented by the following flowchart:

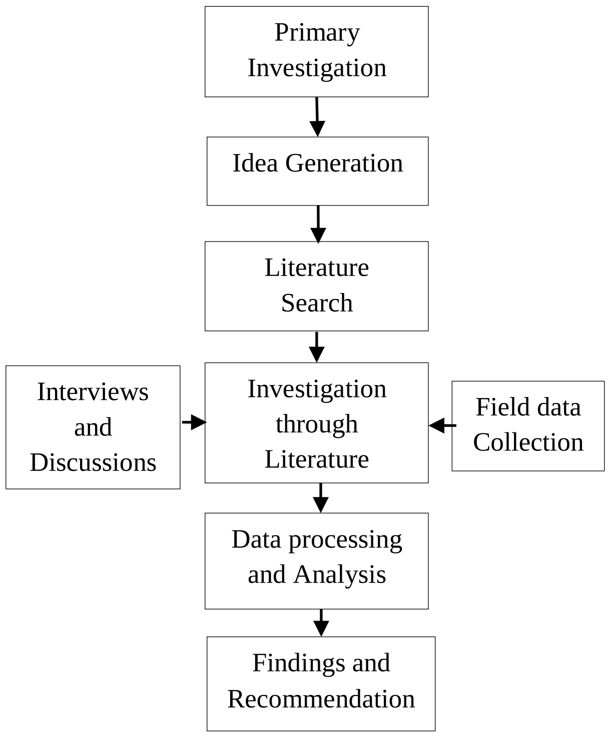

Figure 1: Action plan of the dissertation

3. OVERALL EQUIPMENT EFFECTIVENESS (OEE)

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of a manufacturing process. Developed in the mid1990’s, OEE has become an accepted management tool to measure and evaluate plant floor productivity. OEE is broken down into three measuring metrics of Availability, Performance, and Quality. These metrics help gauge plant’s efficiency and effectiveness and categorize key productivity losses that occur within the manufacturing process. OEE empowers manufacturing companies to improve their processes and

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in turn ensure quality, consistency, and productivity measured at the bottom line. By definition, OEE is the multiplication of Availability, Performance, and Quality.

The formula to calculate Overall Equipment Effectiveness is as follows:

OEE = Availability x Performance x Quality [3]

3.1 Six Major Losses Addressed By OEE

The six major losses, which fall under three OEE loss categories, are discussed at the following table:

Table 1: Six big losses addressed by OEE [4, 5]

Six Major Loss Category	OEE Loss Category	Event Example	Formula to calculate
Breakdowns	Availability	1. Equipment failure 2. Major component failure 3. Unplanned maintenance	$\text{Availability} = \frac{\text{Operating Time}}{\text{Planned Production Time}}$
Set up and adjustments	Availability	1. Equipment setup 2. Raw material shortage 3. Operator shortage	
Minor stops	Performance or, Availability	1. Equipment failure <5mins 2. Fallen product 3. Obstruction blockages	$\text{Performance} = \frac{\text{Net Operating Time}}{\text{Operating Time}}$
Speed loss	Performance	1. Running lower than rated speed 2. Untrained operator not able to run at nominal speed 3. Machine idling	
Production rejects	Quality	1. Scrap 2. Rework 3. In process damage	$\text{Quality} = \frac{\text{Good Pieces}}{\text{Total Pieces}}$
Rejects on start up	Quality	1. Scrap 2. Rework 3. In process damage	

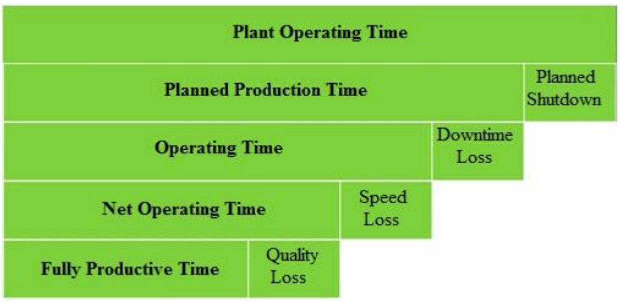

Figure 2: Impact of major losses during production time

4. AN OVERVIEW OF CNC CUTTING SECTION

In Western Marine Shipyard Ltd, CNC cutting system is used in cutting plates of different dimensions in a very orderly manner. The design department prepares the AutoCAD drawing of the parts. Then according to the design, nesting or the positioning of the parts on each steel plate (6000×2500 mm) is done to make the highest use of the plates. After that, nesting drawing and blasted plates are provided to CNC section for cutting.

Figure 3: Activities in the CNC section

In Western Marine Shipyard Ltd. MAX 200 CNC cutting machine is used. The operation process can be represented by the following flowchart:

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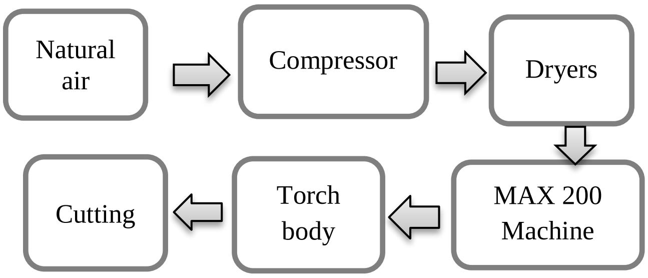

Figure 4: Operation process of CNC cutting

5. ANALYSIS AND RESULTS

We have collected three OEE metric i.e. availability, performance, quality field data. In this purpose, we interviewed the CNC operator and discussed with the appointed engineer of that section if necessary.

5.1 Availability Matrices

We have collected availability data for 5 day (three hour every day) directly from the CNC shop of the shipyard.

Table 2(a): Availability data

Serial	Production Data	Value
01	Shift length (Plant Operating Time: 9.00-12.00; 5 day)	180 ×5=900 min
02	Short break (Planned shutdown)	20×5= 100 min.
05	Change-over time (hh:mm:ss)	00:41:01+00:30:52+00:36:35+00:38:55+00:32:42 =03:00:05 or, 180.08 min.
06	Breakdown (hh:mm:ss)	00:50:57+00:40:40+00:43:53+00:43:24+00:59:13 =03:58:07 or, 238.12 min.

Table 2(b): Availability data

Planned production time	Shift length – Breaks	900 – 100 = 800 min.
Operating time	Planned production time – (Changeover time + Downtime)	800-(180.08+238.12) = 381.80 min.

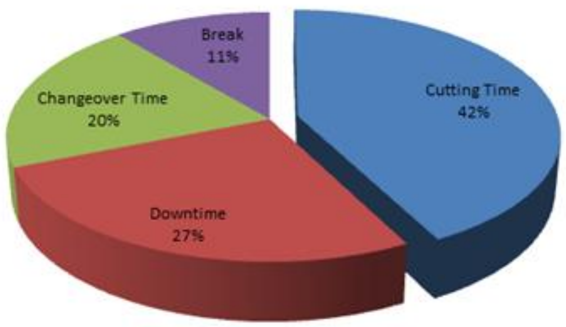

Figure 5: Sub-divisions in plant operating time

The pie chart above exhibits only 42% of the total time is used for cutting, rest 58% time is spent without any value adding operation.

5.2 Performance Matrices

We considered 47 steel plates to calculate performance percentage. The total cutting length is collected from the AutoCAD designs of these 47 plates. The ideal cutting speed is found at CNC machine operating manual and actual cutting speed from the field.

Net Operating Time = Total Cutting Length / Ideal Cutting Speed

Operating Time = Total Cutting Length / Actual Cutting Speed

Table 3: Performance data

Serial	Production Data	Value (hh:mm:ss)
01	Net Operating Time	10:31:33 or, 630.92 min.
02	Operating Time	13:46:45 or, 826.75min.

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5.3 Quality Matrices

Total 620 parts were found after cutting the 47 plates. Rejection report of these parts is collected from the quality control (QC) department.

Table 4: Quality data

Serial	Production Data	Value
01	Total piece	620
02	Rejection/Repair	24
03	Good piece	596

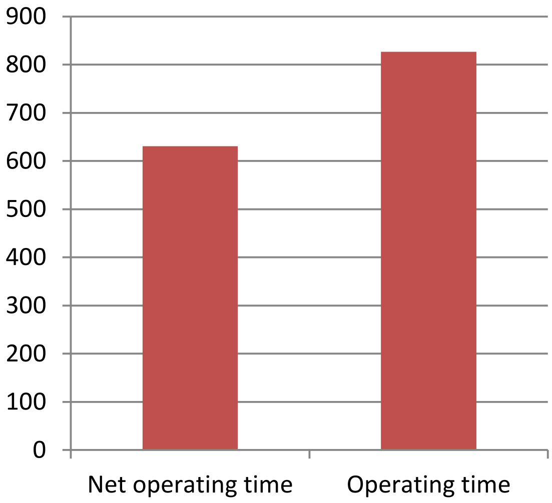

Figure 6: Comparison between net operating time and operating time

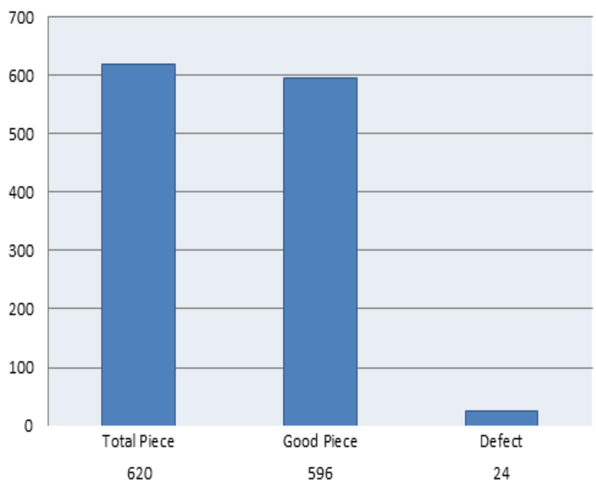

Figure 7: Comparison of total piece, good piece and defective piece

5.4 OEE Matrices

Table 5: OEE calculation

OEE Factor	Calculation	Calculated Data	Percentage
Availability	$\frac{\text{Operating time}}{\text{Planned production time}}$	$\frac{381.80\ min.}{800\ min.}$	0.4773 or, **47.73%**
Performance	$\frac{\text{Net operating time}}{\text{Operating time}}$	$\frac{630.92\ min.}{826.75\ min.}$	0.7613 or, **76.31 %**
Quality	$\frac{\text{Good piece}}{\text{Total piece}}$	$\frac{596}{620}$	0.9613 or, **96.13 %**

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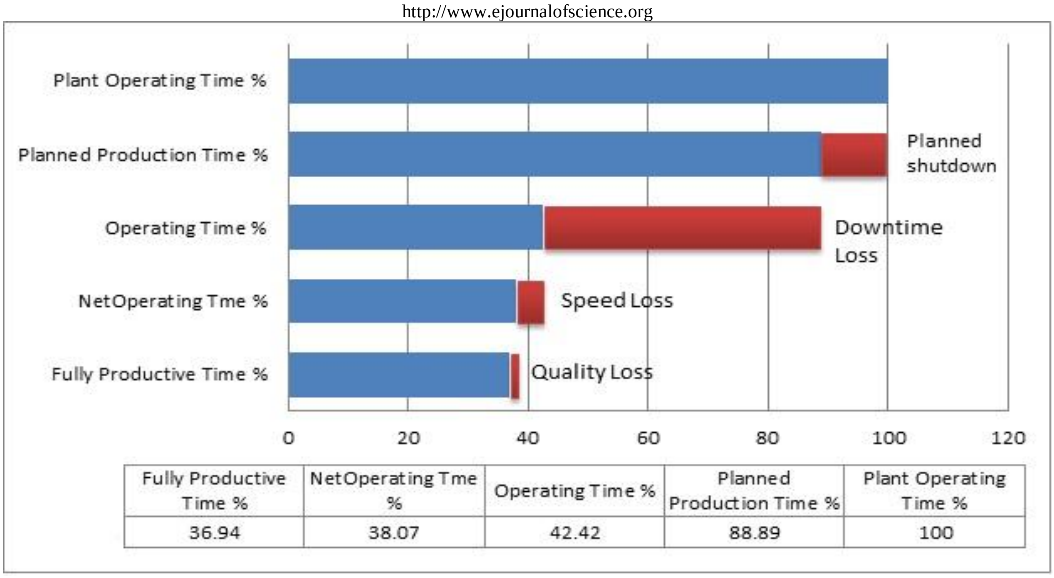

Figure 8: Impact of different losses in the reduction of productive time

The figure above (fig. 4) shows only 36.94% of the total time spent could be considered to be fully productive time. Rest are ellapsed as various kind of losses.

The Overall Equipment Effectiveness
= Availability×Performance × Quality
= 0.4773 × 0.7631 × 0.9613
= 0.3501 or, 35.01 %

5.5 Result

It is found that, the OEE of WMShL is **35.01%** which is far below of the global standard (85% for manufacturing industry) [6]. So, there is much scope for improvement.

6. CONCLUSION AND DISCUSSION

Performance measurement is a fundamental principle of management. The measurement of performance is important, because it identifies current performance gaps between current and desired performance and provides indication of progress towards closing the gaps.

This case study measured the existing performance of the CNC section of the selected shipyard in terms of Availability, Performance and Quality rate by the tool OEE. It is found that the average OEE percentage of CNC section is very low in comparing to world standard. Among the three factors of OEE i.e. Availability, Performance and Quality rate, quality rate was found more satisfactory figure. But a lot of improvement needed to be made in performance and availability. Especially the availability factor is very low due to large changeover time and breakdown. So, the factors lead to availability losses need to be identified and eliminated. Some factors that were identified as liable for productivity loss are mentioned below including specific suggestions to eliminate these:

Factors	Suggestion
1. Changeover delay due to raw material unavailability.	Implementation of 5S program. This will make the raw materials (plate) well organized. So no excess time will be consumed to find out the required plate. Detailed discussion of 5S philosophy (which is a tool of Lean manufacturing technique) is beyond the scope of this paper.
2. Transportation unavailability.	The finished parts are transported via truck. Sufficient number of vehicles should be ensured.
3. Problem of computer of the CNC.	The computer built in with the CNC occasionally gives error due to virus or other problem. Reinstallation of the operating system should be done periodically.
4. Delay in providing new design while a project is just completed.	Computer Integrated Manufacturing (CIM) could be implemented. So, immediately after accomplishing a project the supervisor can upload the next project data to the server and operator can download and use it at once from the

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	shop. Not only for this reason, implementation of CIM will be beneficiary in many other ways.
5. Formation of smoke.	Sufficient number of exhaust fan should be placed in.
6. Delay in electrode change.	Establish telecommunication between machine shop and maintenance department.
7. Delay in setting up reference point.	Building a few certain point on the machine bed indicating reference point.
8. Delay in finding rest plate.	Rest plates should be kept in an organized way under 5S program.
9. Various mechanical problems and breakdown in CNC machine and overhead Crain.	Implementation of Total Productive Maintenance (TPM) program can solve these problems. TPM will grow sense of ownership to the machine operators. So that they will take care of equipment of their own. Also, they will be provided necessary training for basic maintenance operation. Detailed discussion of 5S philosophy (which is a tool of Lean manufacturing technique) is beyond the scope of this paper.

In spite of having very promising opportunity, in the past shipbuilding industry of Bangladesh failed to keep pace with consistency due to lack efficiency in the production system. This had ultimately caused non-penetration in international business as a shipbuilding nation. Much improvement is possible in this field by various Industrial and Production Engineering concept. So, more future research work is necessary for this.

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