Vol. 01, Iss. 4 (2024) 137-141, DOI: 10.61552/JSI.2024.04.001

Journal of Sustainable Development Innovations

www.jsi.aspur.rs

Impact Quality Indicators onto Sustainable Manufacturing

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Keywords:

Quality, sustainable, lead time, efficiency, use resources.

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Received: 3 April 2024
Revised: 17 May 2024
Accepted: 25 July 2024

A B S T R A C T

This paper dealt study effect quality indicators of crushing Limestone process in quarries onto Sustainable Manufacturing. Sustainable Environment was achieving through minimizing quality indicators which were use resources and lead time during crushing of limestone in position. Non-value added time and use resources are studied in this paper. This paper aims to show impact key performance indicators of quality which were production efficiency, efficiency of manufacturing cycle and efficiency of use resources onto Operational and environmental sustainability in order to reduce environmental and operational impacts onto environment and human health. Crushing Limestone process had been employing on one year as a case study to evaluate operational and environmental sustainability of an Iraqi industry. Program of Minitab-Version 17 was employed to analyze information of production process. Results illustrated that the rate of efficiency of utilized resources and waste of resources on one year were 95% and 5%. Conclusions shown lead time was an important performance measure of quality from sustainable Manufacturing perspective.

1. INTRODUCTION

Sustainability is the exploitation of resources in a way which fulfills present requirements and not affects needs of future generations of resources. Sustainable manufacturing can be achieved by implementing quality practices on inputs and manufacturing processes. Efficient use of resources means increasing the manufacturing production volume with fewer resources, in other words providing greater value with fewer inputs, where to achieve that goal requires using less (materials, energy, consumables) to produce the same outputs [1]. Manufacturing firms care about environmental impacts as a priority and do not focus only on sustainability. Through this, it aims to increase environmental awareness in the industrial sector, as the application of sustainable manufacturing has become of

great importance [2]. Three studies dealt with everything related to the key performance indicators under study. Duygu et al., [3] discovered existence of invisible waste on the production line of the clothing company. They employed statistical performance measures to measure process cycle efficiency by calculating lead time. Their results shown key performance indicators of lead time was decreased from 4762 to 2702 minutes, and process cycle efficiency was increased from 0.9% to 1.5% onto production line.

Kliment et al., [4] focused on two key performance indicators were production efficiency and product quality in manufacturing food products. They tested the ability to improve production efficiency of packaging food products on the production line, in addition to optimize quality by applying sensing technology of unwanted objects. They concluded that current productivity has improved from 19.03% to 47.16% as a result of using sensor technology to isolate unwanted materials. Afshari et al. [5] showed that there is a positive relationship between environmental development and improving the total environmental efficiency in industrial organizations. Accordingly, adopting sustainable manufacturing activities encourages organizations to find strategies that enable them to reduce the consumption use resources and increase quality production.

2. METHODOLOGY

Quality indicators represented of production efficiency, manufacturing cycle efficiency and efficiency use resources were employed them to prevent each of waste time and resource consumption in limestone quarries in order to reach sustainable manufacturing. Independent factors represented of lead time and unefficient use resources had passive impact on quality indicators through Crushing limestone processes in position. These indicators had fluctuation effect with operational and environmental performanc indicators in order to reduce lead time and improving use resources, which in turn had a direct impact on achieving the goal of the study, which is to achieve sustainable manufacturing as shown in figure (1).

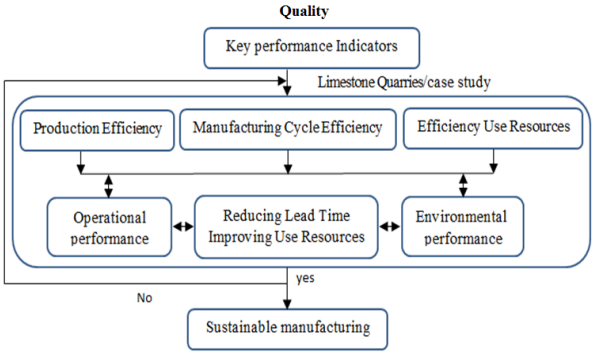

Fig. 1. Quality Methodology to achieve Sustainable Manufacturing

3. PRODUCTION EFFICIENCY

Production efficiency is the station in which the system cannot manufacture more goods without affecting another product. Productivity efficiency is often used synonymously with production efficiency, and this is evidence that the system is operating at its maximum production capacity. Achieving production efficiency in industrial companies requires improving the system for manufacturing products at the lowest cost by improving the use of resources, which has a positive effect on reducing waste and increasing profits [6]. It is very important to measure production efficiency to evaluate the performance of a manufacturing company, relying on quality indicators that enable companies to identify bottlenecks and wasted time and then eliminate them, and improve quality production processes.To determine production efficiency, companies have to compare their actual production volume rate to a standard production volume rate. This may be employed to automated or manual work [7].

4. MANUFACTURING CYCLE EFFICIENCY

Process cycle efficiency means measuring efficiency of production process by measuring the time that adds value to the customer against the used time in activities that do not add value, such as waiting time. Improving manufacturing cycle efficiency has great benefits for industrial companies involves increasing production volume, reducing waste of time, and improving product quality. To calculate manufacturing cycle efficiency of industrial companies have to compare their value added time (processing time) to lead time of throughput [5].

5. RESOURCE EFFICIENCY

Use resources in industry is one of environmental performance indicators that effects onto sustainable manufacturing and represents the relationship between employing limited resources in a sustainable method with reducing their negative impacts on the environment. Efficient use of resources is considered one of the basic elements of competitiveness among industrial organizations. Therefore, efficient use of resources provides significant resources that contribute to reduce the costs of manufacturing operations, improve quality production, and face environmental challenges during production. To calculate resource efficiency must compare between actual and effective production volumes [8].

6. RESULTS AND ANALYSIS

6.1 LEAD TIME AND PRODUCTION EFFICIENCY

Lead time of manufacturing activities faces challenging of breaking hours due to breakdowns that affect productivity of limestone material. Figure (2) illustrated better average of actual production time per day was 5.77 hrs. compared with designed production time per day was 7.14 for each month through one year.

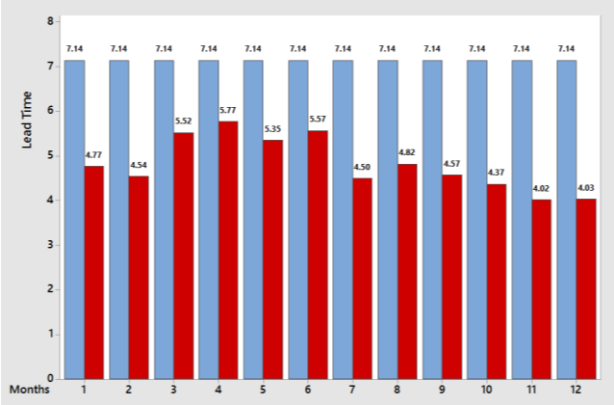

Fig. 2. Lead Time of Production Limestone.

In spite of actual lead time was major in April month but, production volume and efficiency in that month were not major compared with residual months. This means existence waste in time and use resources through manufacturing stage as shown in table (1) which listed standard and actual production volumes. This Table showed effect these independent parameters onto production efficiency.

Table1. *Production Efficiency of the Limestone*

Months	Standard production volume (Tons)	Actual Production Volume (Tons)	Actual Production Efficiency	Optimized Production Efficiency
1	192870	122195	0.633561	0.669135
2	192870	99150	0.514077	0.57419
3	192870	142400	0.738321	0.773122
4	192870	139100	0.721211	0.782164
5	192870	139500	0.723285	0.750516
6	192870	135550	0.702805	0.755037
7	192870	121550	0.630217	0.630705
8	192870	115950	0.601182	0.675916
9	192870	120900	0.626847	0.639747
10	192870	117200	0.607663	0.61262
11	192870	102300	0.530409	0.544802
12	192870	106400	0.551667	0.565148
Total	2314440	1462195	7.581246	7.973101
Mean	192870	132933	0.631771	0.664425

Figure (3) illustrated that major and minor production efficiency of limestone through crushing plant for one year are in May and March months that can be evaluated were good production efficiency 74% and 72%). But, average production efficiency of crushing plant through one year is 63%. which was median approximately. Average production efficiency for one year can be classified as medium at 63%. When manufacturing's firm employed efficient use resources led to minimize lead time of production that used to produce limestone, where average production efficiency optimized from 63 % to 66 % for one year of production. This figure illustrated that production efficiency was equal in July and October months due to efficient use resources.

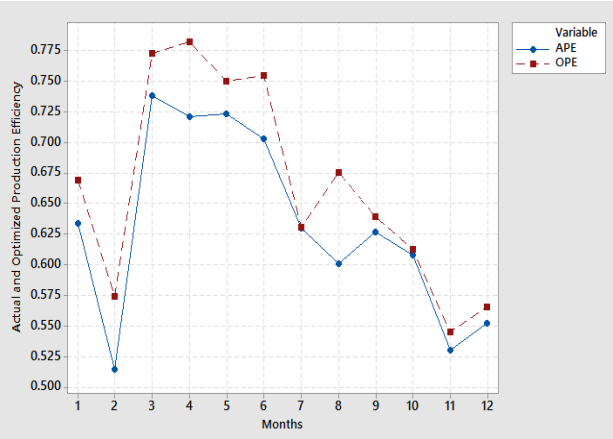

Fig. 3. Actual and Optimized Production Efficiency of the Limestone

6.2 MANUFACTURING CYCLE EFFICIENCY

Table (2) shown the relationship between manufacturing cycle efficiency and waste time throughout effective manufacturing cycle.

Table 2. Comparison Between Lead and Waste Time

Months	Lead Time (hrs.)	Non-Value added Time (hours)	Value added time (hours)	Manufacturing Cycle Efficiency	Waste Time
1	296	24	272	0.918919	0.081081
2	254	33	221	0.870079	0.129921
3	342	26	316	0.923977	0.076023
4	346	37	309	0.893064	0.106936
5	332	39	293	0.88253	0.11747
6	334	26	308	0.922156	0.077844
7	279	9	270	0.967742	0.032258
8	299	41	258	0.862876	0.137124
9	283	6	277	0.978799	0.021201
10	271	10	261	0.9631	0.0369
11	241	14	227	0.941909	0.058091
12	250	13	237	0.948	0.052
Total	3527	278	3249	11.07315	0.926851
WT%					0.077238
MCE %			0.922762		

Figure (4) illustrated that the largest value for manufacturing cycle efficiency was in the ninth month, which considered the least possible of waste time, and the largest waste time was in the eighth month, at a rate of 14%. The rate of manufacturing cycle efficiency and waste time on one year were 92% and 7%.

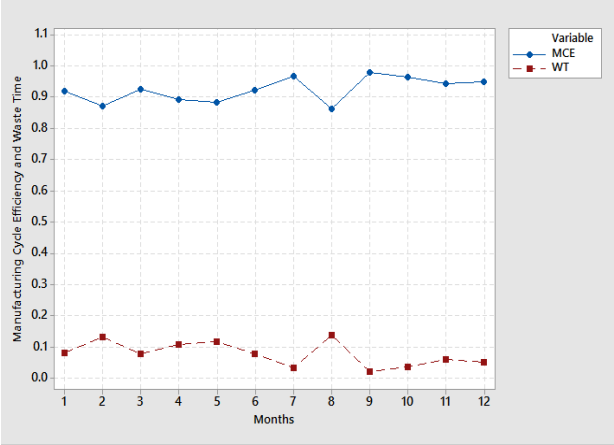

Fig. 4. Manufacturing Cycle Efficiency and Waste Time.

6.3 RESOURCES USE EFFICIENCY

The volume of efficient production and resources that did not add value were listed in Table (3), that illustrated the relationship between resource efficiency and waste resources.

Figure (5) which shown that the largest value for the efficiency of using resources is in the seventh month, which confirms that the waste of materials was the least possible, and the largest waste of materials was in the second and eighth months, at a rate of 10%. The rate of use resources and waste it on one year were 95% and 5%.

Table 3. Value and Non-Value Added Resources

Months	Effective production volume (Tons)	Non-Value added Resources (Tons)	Resource Use Efficiency %	Waste Resources %
1	129056	6861	0.946837	0.053163
2	110744	11594	0.895308	0.104692
3	149112	6712	0.954987	0.045013
4	150856	11756	0.922071	0.077929
5	144752	5252	0.963717	0.036283
6	145624	10074	0.930822	0.069178
7	121644	94	0.999227	0.000773
8	130364	14414	0.889433	0.110567
9	123388	2488	0.979836	0.020164
10	118156	956	0.991909	0.008091
11	105076	2776	0.973581	0.026419
12	109000	2600	0.976147	0.023853
Total	1537772	75577	11.42388	0.576125
WT%				0.04801
RUE %			0.95199	

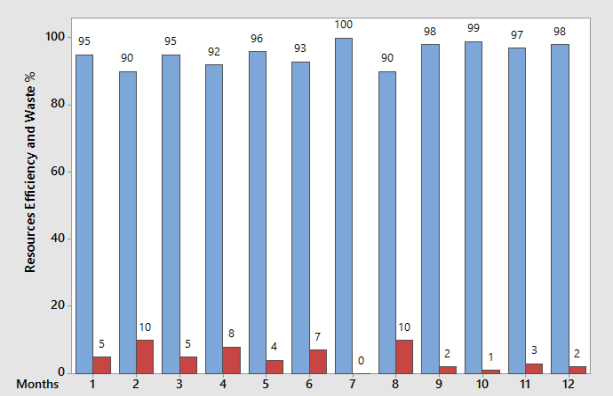

Fig. 5. Resource Efficiency and Waste Resources

7. CONCLUSIONS AND RECOMMENDATIONS

1. Lead time was one of quality indicators that considered an important performance measure because it had a significant impact on operational and environmental performance of sustainable manufacturing.
2. Optimizing production efficiency contributed to reduce lead time and increase effective production volume.
3. Resources cycle efficiency was contributed of sustainable manufacturing of 95% while, the remaining 5% had been non-value added resources through production.
4. Manufacturing cycle efficiency was contributed of sustainable manufacturing of 92% while, the residual 8% had been wasted time due to quality activities that non-value added.
5. Quality indictors contributed to reduce environmental and operational impacts onto environment and human health.

6. Study effect of social and economic performance indicators of quality in other industries from perspective sustainable manufacturing.

ACKNOWLEDGEMENT

I extend my thanks and appreciation to all the workers, technicians and engineers at the limestone quarry site for helping me to access the necessary data to complete my scientific research.

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