Performance Evaluation of a Production Firm Using System Cycle Time Approach

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Abstract

Cycle time has become one of the most critical indicators in competitive manufacturing environments, because it helps management focus on the two key factors in today's marketplace – fully satisfying customer needs and conducting operations as cost efficiently as possible. In this era of build-to specifications, measuring cycle time and reducing non value-adding costs have become important managerial focal points.

This study used the cycle time as a performance measure for a selected firm. The manufacturing process was described using a flowchart and a baseline for the critical activities which affect the cycle time for a batch production was established. After that, the activities were evaluated against the target to show current status. Factors which affect the times of these activities were also considered.

The results show that on the average 30% of the manufacturing process did not meet with the time set for them and that each step in the process has a 45% chance of meeting its target time. This will reduce the average cycle time for a shift from 521 to 435 minutes, which is a 16.51% reduction.

This work investigated the performance of manufacturing firm using cycle time approach.

Keywords: Performance, cycle time, batch.

1. Introduction

1.1 Preview

Performance is considered an umbrella term for all terms covering the success of a company and its activities. Its measurement is a fundamental and important principle of management which identifies gaps between current and desired performance level and provides indication of progress towards closing the gaps.

Globalisation is posing several challenges to the manufacturing sector. In today's competitive marketplace, manufacturers strive to fully satisfy their customers' needs as cost efficiently as possible. The design and operation of manufacturing systems are therefore of great economic importance to this objective.

A manufacturing system is a set of machines, transportation elements, computers, storage buffers and other elements that are used together for manufacturing including human labour (Muthiah and Huang, 2006). Some of these elements are difficult to predict and control due to factors such as the supply and cost of raw materials, the effect of continually developing technologies, changes in the global market, and human behaviour and performance.

When considering performance in relation to a manufacturing facility, the terms productivity and performance are usually tightly interlinked. However, productivity strictly deals with the relation between output and input resources, while performance covers all aspects of cost, flexibility, speed, reliability and quality (McNair *et al*., 1990; Neely, 1999; Anyaeche, 2006).

Performance measures in a manufacturing system are the measurable parameters (metrics) and they include the throughput time/production rate, cycle time, work-in-process inventory, percentage on-time delivery, percentage defective, periodic production volumes, and total/unit costs (Anyaeche, 2006; Adegbilero, 2012).

Performance measurement is a fundamental principle of management. It is important because it identifies gaps between current and desired performance and provides indication of progress towards closing the gaps. Carefully selected key performance indicators identify precisely where to intervene to improve performance (Weber and Thomas, 2005).

1.2 Problem Statement

Financial measures such as profit and return on investment, generally used as traditional factors, for long have been the focus of performance measures in manufacturing organizations. These measures, though important, are not as directly related to customer satisfaction as the non-financial parameters such as quality, cycle time, delivery time, etc. which give an organisation competitive edge and customer loyalty (Neely, 1999). In this work a non-financial factor, cycle time is used for performance evaluation in a selected production firm.

1.3 Aim and Objectives

The objectives of this work are:

i. Evaluate the performance of a selected firm using the cycle time.
ii. Make appropriate recommendations from the evaluation.

2. Performance Measurement Systems

Performance measurement is defined as the process of quantifying the efficiency and/or effectiveness of an action (Muthiah and Huang, 2006). Performance measurement systems are those sets of metrics used to quantify the efficiency and effectiveness of an action. The variety, diversity and complexity of manufacturing operations make it difficult to have a perfect performance measure (or a set of measures) which is applicable to all situations.

2.1 Reasons for Performance Measurement

Some vital reasons for measuring performance, include the following (Moges, 2007):

i. Strategy formulation
ii. Management of the strategy implementation process

iii. Challenging assumptions (this is by focusing not only on the implementation of an intended strategy but also on making sure that its content is still valid)
iv. Checking position
v. Complying with the non-negotiable parameters of survival such as legal requirements, environmental parameters, etc.
vi. Communicating directions to the employees
vii. Communication with external stakeholders
viii. Provision of feedback
ix. Evaluation and reward of behaviour
x. Benchmarking the "best practices" of performance;
xi. Informing managerial decision-making processes; and
xii. Encouraging improvement and learning.

2.2 Performance Measures

The development of performance measurement can be divided into two main phases. The first phase performance measures were derived from management accounting systems and emphasized cost, focusing on financial measures such as productivity, profit and return on investment. At the latter stages of the 20th century, globalization began to change the rules of business as companies were loosing market shares to competitors elsewhere who were able to offer products with higher quality and wider range at lower cost, especially overseas competitors. This led to trade barriers being torn down and competition among companies moved to the international arena with the world, and not only their nations, as their market (Neely, 1999).

The second phase of performance management literature focuses more on operational indicators such as delivery precision, lead time, flexibility and quality. Thus, new production technologies and philosophies such as just-in-time, total quality management and optimized production technology were introduced and implemented (Fullerton and McWatters, 2002).

A performance measurement system can be defined as the organized means of defining, collecting, analyzing, reporting, and making decisions regarding all performance measures within a process. Different types of performance measurement frameworks have been developed over the years. Some of them include the Balanced Scorecard by Robert Kaplan and David Norton in 1992, the performance measurement matrix by Keegan *et al.* in 1989, the results and determinants framework by Fitzgerald *et al.* in 1991, and the Lynch and Cross' performance pyramid (Neely et al. ,2002).

Performance measures quantitatively tell us something important about our products, services, and the processes that produce them. It helps to understand, manage, and improve what organizations do. The characteristics include: inclusiveness (measurement of all pertinent aspects), universality (allow for comparison under various operating conditions), measurability (data required are measurable), and consistency (measures consistent with organization goals). The categories include quality, time, flexibility, and cost (Beamon, 1999).

Many areas in the manufacturing process can be measured, but only a few contribute to meaningful improvement. The key performance measures include:

i. Quality,
ii. Cost,

iii. Cycle time, and
iv. delivery performance,
v. safety

All others are subordinate. Activities and efforts in manufacturing that result in improving one or more of these performance measurements, without reducing performance to any of the others, support good performance.

2.3 Performance Metrics

The metrics used in this work include: Cycle time, work in progress, throughput etc. These are further explained in the following passage.

2.3.1. Cycle time

The Cycle time (CT) has been defined as the length of time between starting and finishing the production of an order (Brabazon, 1999). This is the average time a product spends in the system as WIP. This time to process an order must be monitored carefully, both to ensure efficient performance as well as to evaluate possible design changes in light of new materials and technology.

2.3.2 Little's Law

Conventional performance metrics used to measure factory performance are production throughput (λ), process inventory (L), cycle time (W). The relationship between these is given by Little's law (Muthiah and Huang, 2006).

$$L = \lambda W \qquad (1)$$

i.e. WIP = throughput × cycle time

TH = Throughput (arrival rate).

This is the velocity or speed of production which is the output per unit time of the production system. It is calculated by determining how many items are produced and dividing this by the length of time it took to produce them, but it can of course, be computed from Little's Law;

$$TH = WIP/CT \qquad (2)$$

WIP = Work in Process (average number of units/customers in a system).

This is the number of items currently in production or being serviced in some way. Again, this figure must be measured (counted) directly or can be computed from Little's Law which states, $L = \lambda W$

Little's law is extremely general. In the opinion of Hopp (2003), the only two restrictions on it are:

i. It refers to long-term averages. This simply means that Little's law need not necessarily hold for daily WIP, throughput, and cycle time, but for averages taken over a period of weeks or months it will hold.
ii. The process must be stable. This means that the process cannot be exhibiting a systematic trend (e.g., steadily building up WIP, increasing the throughput rate, or anything else that makes the process substantially different at the end of the data collection interval than it was at the beginning) during the interval over which data were collected. However, this stability restriction does not rule out cyclic behavior (e.g., WIP rising and falling), bulk arrivals, batch processing, multiple entity types with different characteristics, or a wide range of other complex behavior.

Indeed, Little's law is not even restricted to a single process. As long as WIP, throughput, and cycle time are measured in consistent units, it can be applied to an entire line, a plant, a warehouse, or any other operation through which entities flow.

3. Methodology

The production process was examined to establish the flow process, identify the critical activities, data collected and analysis carried out. The detail methodology is as stated below (DOE, 1995).

The steps are as follows:

i. Identify the process flow. This is the first and perhaps most important step.
ii. Identify the critical activity to be measured. The critical activity is that culminating activity where it makes the most sense to locate a sensor and define an individual performance measure within a process.
iii. Establish performance goal(s) or standards. All performance measures should be tied to a predefined goal or standard, even if the goal is at first somewhat subjective. Having goals and standards is the only way to meaningfully interpret the results of the measurements and gauge the success of your management systems.
iv. Establish performance measurement(s). In this step, we continue to build the performance measurement system by identifying individual measures.
v. Identify responsible party(s). A specific entity (as in a team or an individual) needs to be assigned the responsibilities for each of the steps in the performance measurement process.
vi. Collect data. In addition to writing down the numbers, the data were pre-analyzed in a timely fashion to observe any early trends and confirm the adequacy of the data collection system. The process of collecting data used the guideline which was published by the Department of Energy (1995) adopting to the internal processes to best fit within their operations.
vii. Analyze/report actual performance. In this step, the raw data were formally converted into performance measures, displayed in an understandable form, and easy dissemination.
viii. Compare actual performance to goal(s). In this step, compare performance, as presented in the report, to predetermined goals or standards and determine the variation as appropriate.
ix. Establish area for corrective actions Depending on the magnitude of the variation between measurements and goals, some form of corrective action may be required.
x. Make changes to bring back in line with goal. This step only occurs if corrective action is expected to be necessary. This step is primarily concerned with improvement of the management system.
xi. Establish new goals needed. Even in successful systems, changes may need to be revised in order to establish ones that challenge an organization’s resources. Goals and standards need periodic evaluation to keep up with the latest organizational processes.

4. Application

The core manufacturing activities of the company were identified and selected for time study. Some steps in the process were broken down into their constituent activities. The flow chart in fig 1 shows the activities measured during the time study.

4.2 Data Collection

The company selected as case study is a bakery in Southwest Nigeria. The guideline in section 3 above was adapted in carrying out the study in the organization. The data and information used in the study were collected through an interview of the manager and other staff of the bakery as well as carrying out a time study of the activities identified in the manufacturing process.

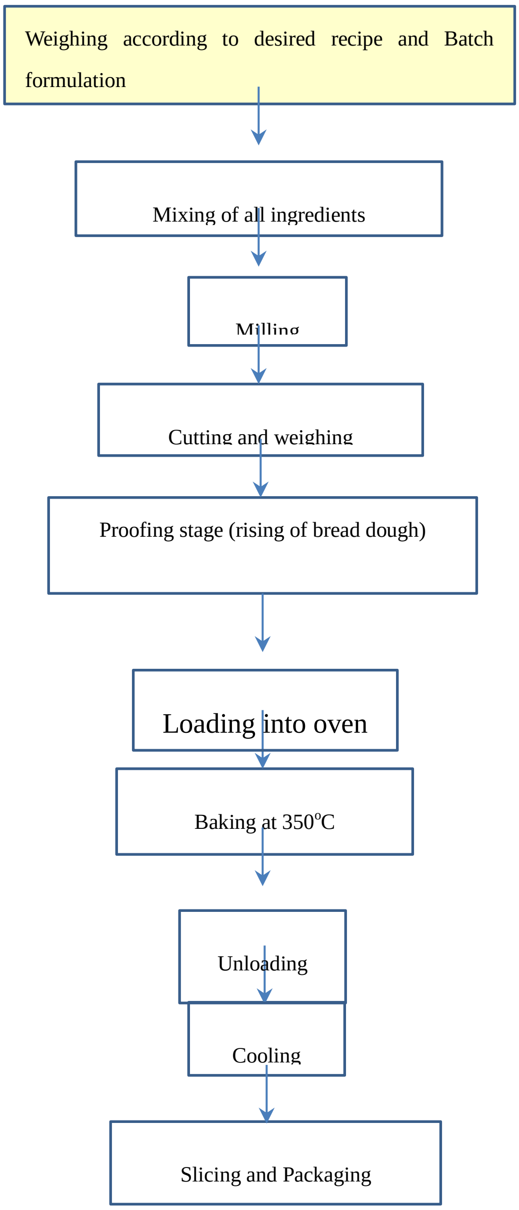

Fig. 1: Activities which were measured during the study

From the analysis of each of the activities, it was found out that for the first batch of the shift, the mixing process was on time for 4 out of the 6 days; the milling, cutting and weighing processes were on time for 2 out of the 6 days, and loading and unloading for 3 out of the 6 days.

For the second batch, the mixing and milling processes were on time for 2 out of the 6 days; while the rest of the activities were on time for 3 out of the 6 days. Also, the average time for each of the activities for the duration of the study did not meet the set target.

Table 1: Target time set for each measured activity.

	ESTABLISHED BASELINE		
Time/Clock (mins)	**Operation/Process**	**Completed Activity**	**Time Taken (mins)**
0	Weighing and batch formulation starts		
30	Mixing starts		
70	End mixing; start milling	Mixing	40
90	End milling; start cutting and weighing	Milling	20
150	End cutting and weighing; leave to prove; weighing and batch formulation for batch 2 starts	Cutting and weighing	60
180	Start mixing batch 2		
210	load batch 1 into oven and bake	Load batch 1	40
220	End mixing batch 2; start milling batch 2	Batch2 Mixing	40
240	End milling batch 2; cut and weigh batch 2	Batch2 Milling	20
270	Unload batch 1 & leave to cool	Unload batch 1	30
300	End cutting and weighing batch 2 and leave to prove	Cutting and weighing batch 2	60
360	start slicing and packaging batch 1; load batch 2 into oven and bake	Load batch 2	40
420	unload batch 2 and allow to cool	Unload batch 2	30
510	slice and package batch 2		

5.0 Results and Discussion

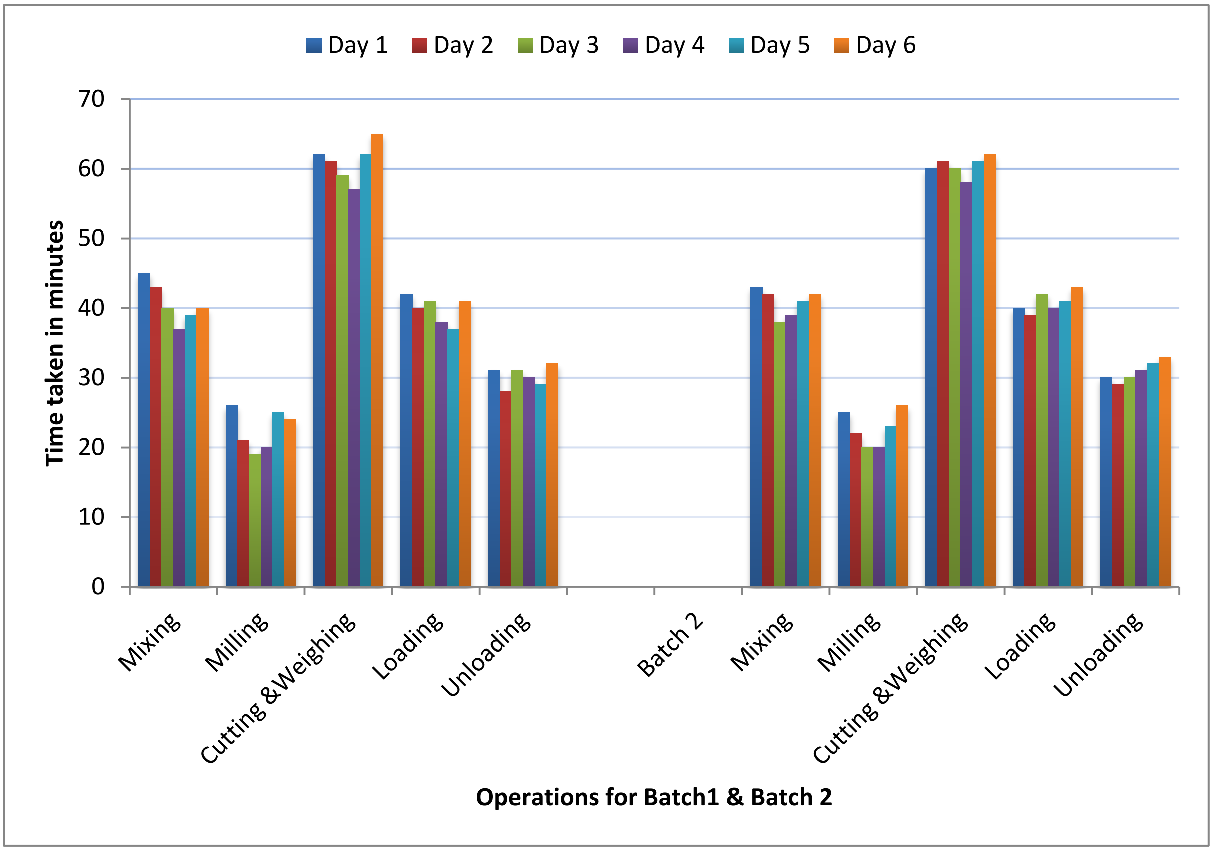

Fig. 2: Chart showing the various activities and time taken to complete them

4.2 Data Analysis

Analysing each activity that was measured, it was seen that for the first batch of the shift, the mixing process was on time for 4 out of the 6 days; the milling, cutting and weighing processes were on time for 2 out of the 6 days, and loading & unloading for 3 out of the 6 days.

For the second batch, the mixing and milling process were on time for 2 out of the 6 days; while the rest of the activities were on time for 3 out of the 6 days. Also, the average time for each of the activities for the duration of the study did not meet the set target. This is shown in the table 3 below.

Table 3: Table showing the times which met the target

Batch 1	Target value	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Average	% time on tarsget
		TIME IN MINUTES							
Mixing		45	43	40	37	39	40	41	66.67
Milling		26	21	19	20	25	24	23	33.33
Cutting &Weighing		62	61	59	57	62	65	61	33.33
Loading		42	40	41	38	37	41	40	50
Unloading		31	28	31	30	29	32	30	50
Batch 2									
Mixing		43	42	38	39	41	42	41	33.33
Milling		25	22	20	20	23	26	23	33.33
Cutting &Weighing		60	61	60	58	61	62	60	50
Loading		40	39	42	40	41	43	41	50
Unloading		30	29	30	31	32	33	31	50

Further analysis of the data show that averagely over the period of study, 30% of the steps in the manufacturing process of the system do not meet the target set for them to achieve the overall goal for the measurement of performance. It is also seen that during the period of the study, each time study carried out for a step in the manufacturing process has a 45% chance of meeting the target set for it.

This shows that there is need for a reduction in the time taken by some of the steps in the process to achieve the goal set for the performance evaluation.

5. Conclusion and Recommendations

5.1 Conclusions

Having completed this study, the following conclusions are made:

i.) The literature review has shown some of the performance measures in a manufacturing which include measures of quality, cost, time, delivery performance and also measures of safety. Activities and efforts in manufacturing that result in an improvement in one or more of these performance measurements, without degrading the performance of any of the others, will improve the overall performance of the organisation.

ii.) The analysis on the data collected from the manufacturing system over the period of study shows that on the average, 30% of the steps in the manufacturing process of the system do not meet with the goal set for them to achieve the overall goal for the measurement of performance. It also shows that during the period of the study, each time studied for a step in the process has a 45% chance of meeting the target set for it.

5. 2 Recommendations

The following are the recommendations concerning those processes which on the average did not meet their set target during the study

i.) The idle mixer in the production floor should be repaired and put to use to reduce the mixing time in the production process.

ii.) The cutting and weighing operations appear to be very repetitive and cumbersome operations in the production process. Automating these operations would significantly reduce the time spent on it.

iii.) A proposed layout to improve the system's performance is referred for further work.

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