Application of Work Study for Productivity Improvement: A Case study of a Brewing Company

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Abstract— Productivity focuses on the efficient use of resources; labor, land, materials and energy for the production of various goods and services. The brewing process of the company under study had been taking longer than the standard time hence affecting productivity. The researchers focused on identifying areas for productivity improvement using work-study. The boiler, brewing and packaging sections of the production department were investigated. A descriptive research was conducted in which interviews; direct observations and work sampling were used to collect data. A sample size of 75 observations was determined using a statistical formula. Out of the 75 observations conducted at the boiler, brewing and packaging sections, the researchers concluded that; for the boiler section, 68% of the time the workers were working while the remaining 32% was attributed to ineffective time. For the brewing section, 60% of the time the workers were working while 40% was attributed to ineffective time. For the packaging section (machine 1), 80% of the time, the workers were working while 20% accounted for ineffective time. Lastly for the packaging section (machine 2) 83% of the time, the workers were working while 17% accounted for ineffective time. The findings separated employee's and machine working time from idle time. The researchers recommended that the company acquires advanced material handling systems; invest in sustainable energy and employee training especially in productivity improvement programs so as to enhance worker skills and knowledge.

Keywords: *Brewing, Productivity Improvement, Work study, Work Sampling*

I. INTRODUCTION

In a globalized economy, competitiveness means an ability to take the most advantageous position in a constantly changing market environment. Competitiveness is based on quality, speed, technical superiority and product differentiation. In the ultimate analysis though, one of the major determinants of competitiveness, whether at national, industrial or firm level, is raising productivity. According to [1] productivity is the efficient use of resources; labor, land, capital, materials, energy for the production of various goods and services. He further adds that productivity refers to the relationship between results and time it takes to accomplish them. The lesser the time it takes to achieve the desired results, the more productive the system is; the opposite is also true. Reference [2] also affirms that productivity is "doing more with less". He further adds that productivity can be measured using different techniques and one of these techniques is work study. According to [3], work study is a systematic examination of the methods of carrying out activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried out. It constitutes of method study and work measurement. Reference [1] alluded that work measurement can be conducted using different techniques such work sampling. Work sampling is a technique that measures the time individuals spend in various categories of activities. It is mainly used to analyze how workers utilize their time, but can also be used to study managers for the same reason [4]. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity or delay, is a measure of the percentage of time during which that activity delay occurred. One advantage of work sampling is that it provides an easy and inexpensive way to analyze work. It is mainly used in analyzing repeative and non-repeative occurring activities [5]. The key objective of using work sampling is to determine how time is being employed by the work force [5]. Another objective is to identify problem areas that cause delays and to allocate managerial attention to these areas [5]. Work sampling has also been used for measuring productivity, especially during the 1970s and 1980s, and for evaluating which method of two or more alternatives is most productive [4]. Further, [6] and [7] argues that work sampling studies can be used for finding trends in productivity over time.

The productivity of the company under study had reduced due to the fact that the brewing process had been experiencing prolonged brewing process time as compared to the standard time. The brewing and packaging targets for the company under study were only met on an average of four days in a week as a result of delays in the production and packaging processes. Further, according to [8], evidence has suggested that today's leading economies such as China, Republic of South Africa etc

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have adopted productivity as an integral strategy for sustainable socio-economic development. Therefore the research came at a time when the manufacturing sector of Zambia is facing challenges and conducting such a research would contribute to the much needed solutions for Zambia.

The brewing and packaging sections of the production department were the main area of focus. Work sampling was conducted in these sections to identify areas where ineffective time was a challenge. Figure 1 depicts the brewing process of beer. Raw materials such as water, mealie meal, malt, AMG (enzyme) and yeast are used in the making of beer. One brew requires 44-50kg bags of mealie meal, 1 bag of malt (60kg), 1.25 liters of AMG,

10 kg yeast and 0.55 tones (550 kg) of coal for use in the boiler section. The raw materials are poured into the hopper. Steam from the boilers is used to heat the cookers which are used during the preparation of the ingredients mixed with boiling water. The preparation takes 2hours 30minutes. After 2 hours, the prepared wort (porridge) is then drained into the convertors and it takes another 1 hour and then the straining process is started. Vibro screening is a straining technique used and it takes 2 hours depending on the thickness of the wort (porridge). The straining process is continued through to the fermenters. Fermentation is done to convert the wort into beer and it takes about 8 hours for the process to be complete.

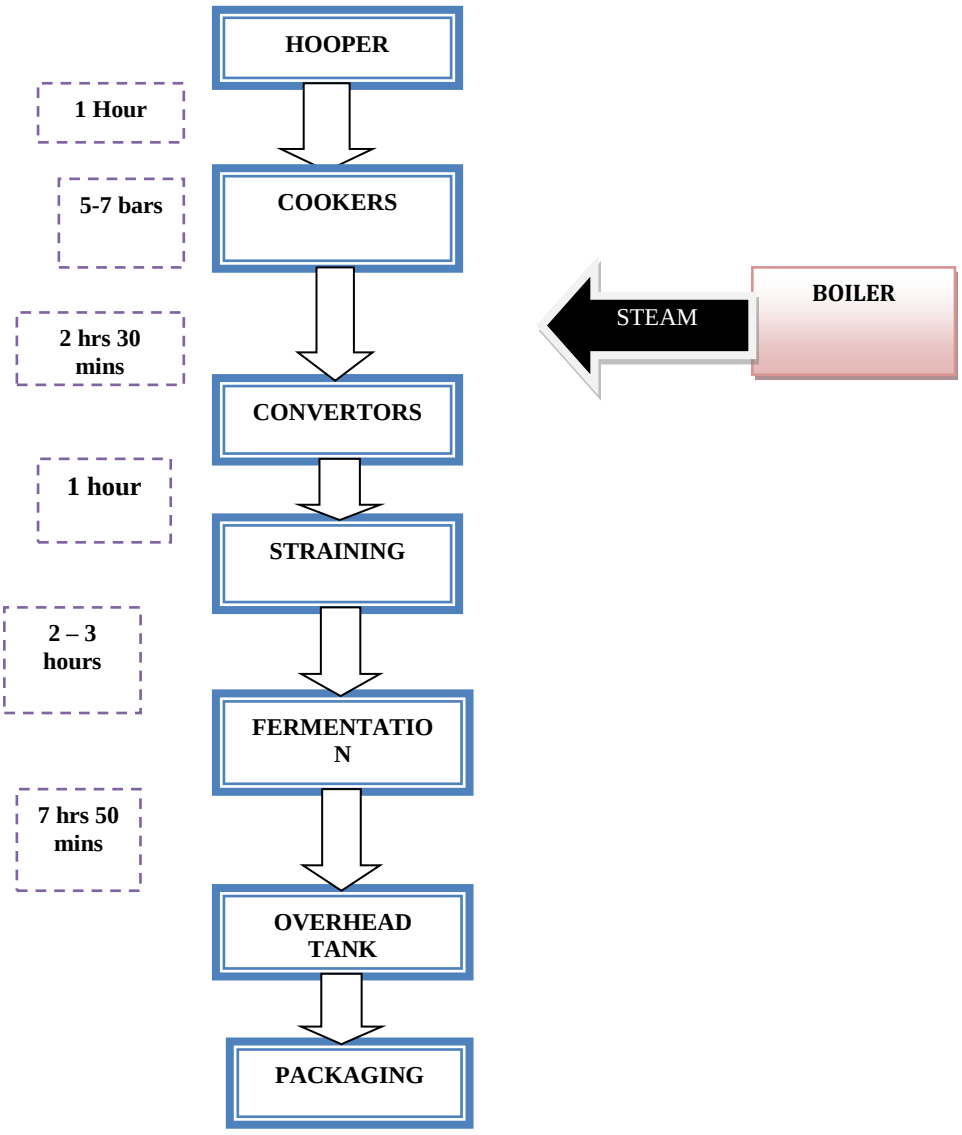

Fig 1: Standard Brewing Process

The focus of the study was to investigate the causes of the delays during the brewing and packaging processes. The researchers used work sampling method to identify areas for productivity improvement in the brewing and packaging sections of the plant.
The paper begins with a review of literature on work sampling studies, followed by the methodology. The results and discussion follows and finally the conclusion and recommendations.

II. LITERATURE REVIEW

Reference [4] conducted a study on "why do work sampling in construction? The case of plumbing work in Scandinavia. The findings of the research indicated that, work sampling studies are of little value for measuring productivity as well as for comparing performances over time. One reason is that the conditions vary to a high extent from one situation to another. Another reason is that working conditions undergo significant development over time. On the other hand, the authors experience that data from work sampling studies are of high relevance for discussions on improvement opportunities among workers as well as among corporate managers. Reference [9] conducted a study in which work sampling was conducted on bricklayers, plasters, concrete-workers, painters and roof joiners. 30 craftsmen in each category were used. The results indicated production time (building, handling materials, clean-up, unloading) at 40%, statutory ancillary time (official break, increment weather) 14%, support ancillary time (supervision, material distribution, setting out, testing) at 14% and non-value adding time (absent, waiting, not working) at 33%.

1) Reference [10] studied how construction workers use their time in constructing load-bearing structures, roofs and facades. The results of the study indicated that direct value-adding including correcting defects was 20%, preparations including indirect work, material handling and work planning was 45%, waste including waiting, moving between working spots and unexploited time was 35%.
Reference [11] conducted a study in which work sampling was used for a period of three months in Canada during the installation of drainage pipes. The results indicated that 32% attributed to value adding and 68% to non value adding processes.
The results from [9] and [10] both indicate non- value adding tasks contributing the second highest percentage after the analysis. In the case of the results from [11] non-value adding tasks contributed the highest value of 68%. The difference in the results can be supported by [4] statement that, conditions vary to a high extent from one situation to another. It is clear that work sampling can be used to indicate the position of the activities at different work environments. Even though the periods and environments in which the studies were conducted are different, the results can be used to effect improvement in the areas identified. According to [4], the data from work sampling studies are of high relevance for discussions on improvement opportunities among workers as well as among corporate managers. As a result of the results from work sampling having a high relevance for discussions on improvement, the researchers of the study decided to use work sampling in order to investigate and identify activities were improvement were needed in order to improve productivity. Also the studies reviewed indicate that the studies were conducted in the construction industry while the study at hand is in the brewing and packaging industry. The research at hand focused on answering the following key questions; what are the intervention areas for productivity improvement? What are the causes of idle time? How can the current methods of work be improved?

III. METHODOLOGY

A descriptive research design was employed while quantitative and qualitative approaches were used. Interviews, direct observations and work sampling were used for data collection.

A. Structured Interviews

Table 1 shows the sample questions used during the process of conducting interviews with the production manager, production supervisors and the general workers.

Table 1: Sample Interview Questions

1.	**What is the brewing process?**
2.	**What steps are involved in the brewing process?**
3.	**How long does it take for the each step to be completed?**
4.	**Is it necessary to undertake all the steps?**
5.	**Is it critical that all tasks are done at a particular and stated time or is there flexibility in time sequence?**
6.	**Could one step be combined with some other steps in the process?**
7.	**Is there another way of undertaking each task?**
8.	**Should the worker be of a higher or lower skill level?**
9.	**What training or skill development programs is the company undertaking?**
10.	**How is machine downtime affecting productivity?**
11.	**What maintenance strategies are being used?**
12.	**How is quality affecting productivity?**

B. Direct Observation

Under this method, the researchers observed the production processes in particular the brewing process and the manner in which the workers conducted their work. This method was opted for because the researchers were able to observe and record events without relying on the respondents' willingness and abilities to report. Also elements of human error reduced as the processes and methods were observed directly.

C. ***Work Sampling***

As evidenced by the brewing sheets and the on-site observations which were taken, it was observed that the brewing process was taking longer than the standard of 15 hours/brew. From the selected data that was observed, the ineffective time was calculated to be 7 hours while on the other data sheet; it was calculated at 3 hours.

The main objective of using work sampling was to determine whether a given worker or machine was idle or working and in this case, observations were aimed at detecting one of the two possibilities (figure 2), which also shows the causes of worker/ machine idleness.

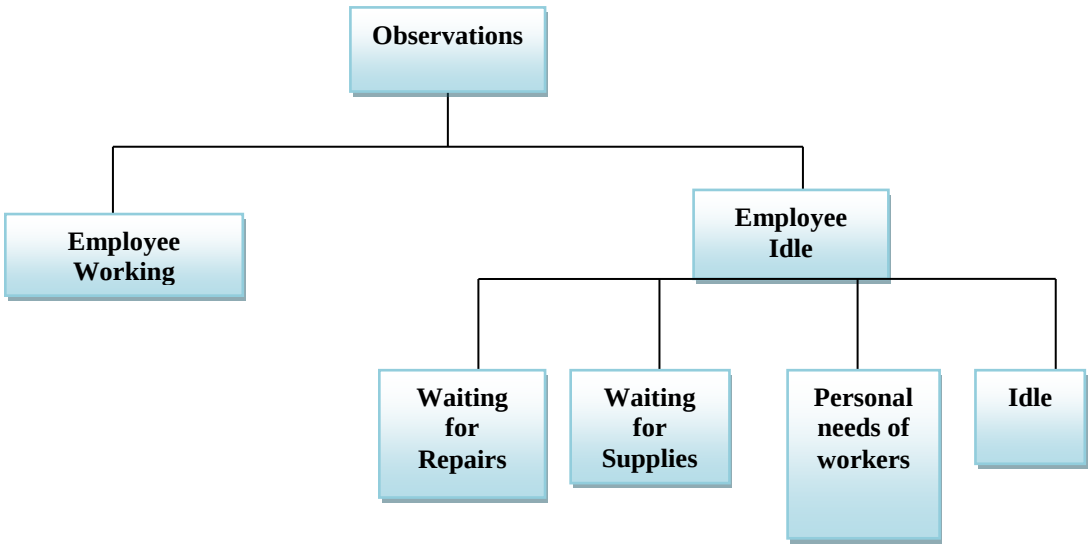

Fig 2: Worker/machine working or idle model

The sample size for the observations to be conducted was determined using the confidence level determined on the margin of error that could allow for these observations to be done. 95% of the time a particular observation was considered to be correct within ±5 %, or 10 %. A statistical formula "(Eq1)" was used to determine the standard error of proportion.

$$\sigma_p = \sqrt{\frac{pq}{n}} \quad (1)$$

In order to use the formula above, the values of *p* and q needed to be known and therefore, a number of random observations were carried out in the working area. 20 observations were randomly carried out as a preliminary study and they showed a 25% of workers idleness in all the cases (p = 25) and a 75% of workers working (q = 75). Having determined the values of *p* and *q*, the value of n needed to be determined but, the value of *op* had to be determined first. A confidence level of 95 % with a 5 % margin of error was chosen in which 95% of the cases the estimates were ± 5 % of the real value. At the 95 % confidence level:

$$1.96\,\sigma_p = 10$$
$$\sigma_p = 5$$

Going back to our original "(Eq 1)", we determined *n:*

$$\sigma_p = \sqrt{\frac{pq}{n}}$$
$$5 = 25x75$$
n = 75 observations

To ensure that the observations were made at random, a random table was used (Table 2). In this case the observations were carried out during a day shift of twelve hours, from 06:00hrs to 18 hours. Taking a twelve-hour day shift to have 720 minutes, these were divided into 48 minutes intervals, 15 visits per day over a period of 5 days from Monday to Friday were conducted.

Table 2: Time of observation from the random table numerical order

Number Selected from Random Table	Arranged in Numerical Order	Time of Observation
33	**5**	**6:50 hrs**
38	**11**	**7:50 hrs**
46	**14**	**8:20 hrs**
25	**15**	**8:30 hrs**
45	**20**	**9:20 hrs**
5	**22**	**9:40 hrs**
49	**26**	**10:20 hrs**
15	**33**	**12:20 hrs**
47	**38**	**14:30 hrs**
22	**39**	**14:50 hrs**
41	**42**	**15:05 hrs**
25	**43**	**15:50 hrs**
20	**45**	**16:20 hrs**
48	**46**	**17:00 hrs**
43	**48**	**17:15 hrs**

IV. RESULTS

A. Boiler Section

Figure 3 below shows the results of the 75 observations which were conducted at the Boiler section. Out of the 75 observations over a period of 5 days the results showed that 68% of the time the workers were working, 8% workers were idle as a result of waiting for repairs, 3% workers were idle due to waiting for supplies, 3% workers attended to personal needs and 18.0% workers were idle but there was no reason attached to it.

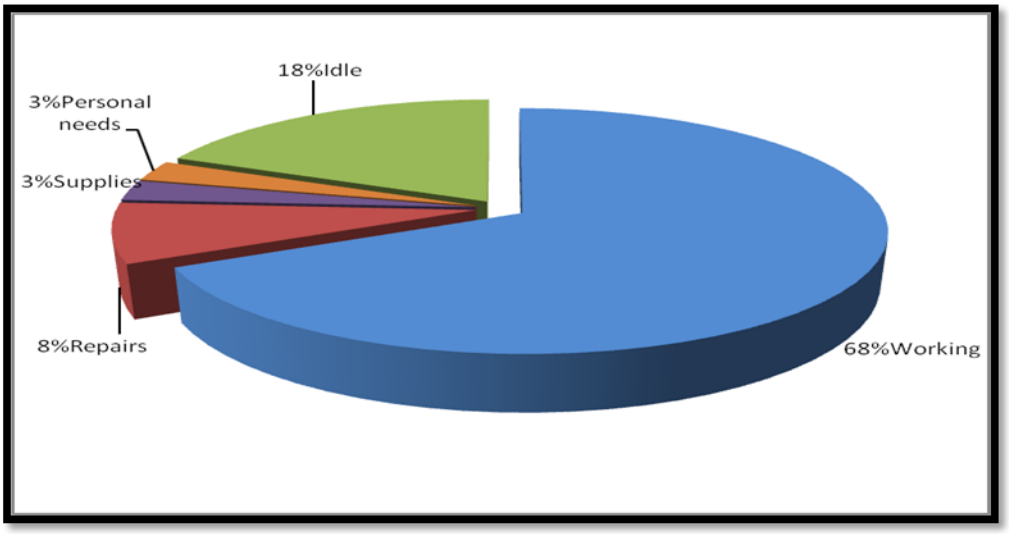

Fig 3: Boiler Section Observations

B. Brewing Section

Figure 4 below shows the results of the 75 observations which were conducted at the Brewing section. Out of the 75 observations over a period of 5 days the results showed that 60% of the time, the worker was working, 6.7% worker idle waiting for repairs, 6.7% worker idle waiting for supplies, 2.6% workers attending to personal needs and 24% workers were idle for no reason.

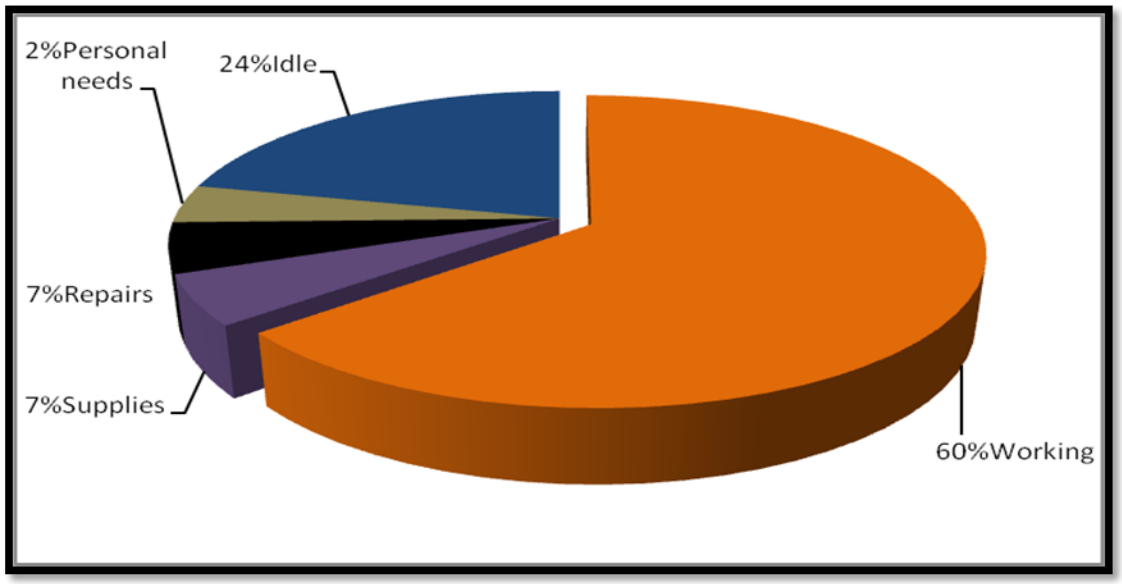

Fig 5: Brewing Section Observations

C. Packaging Section Machine 1

Figure 5 below shows the results of the 75 observations which were conducted at machine 1 of the Packaging section. Out of the 75 observations over a period of 5 days the results showed that 80% of the time machine was working, 4% machine

downtime, 6.7% machine idle waiting for supplies, 1.3% machine operator attending to personal needs and 8% machine idle for other reasons not indicated.

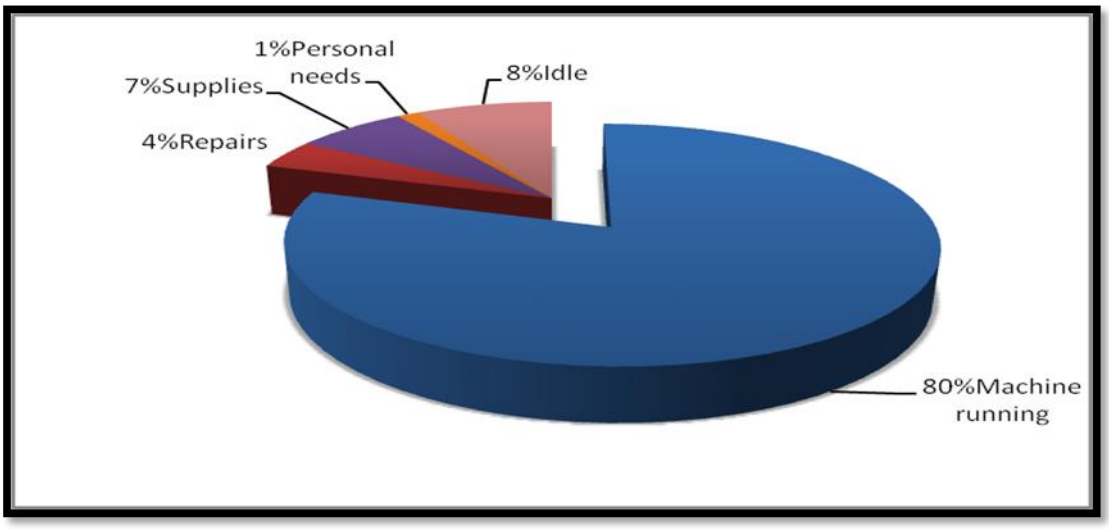

Fig 6: Packaging Section Observations at Machine 1

D. Packaging Section 2

Figure 6 below shows the results of the 75 observations which were conducted on machine 2 at the Packaging section. Out of the 75 observations conducted over a period of 5 days the results showed that 83% of the time machine was running, 5.3% machine downtime, 5.3% machine idle waiting for supplies, 2.6% machine operator attending to personal needs and 4% machine idle for other reasons not indicated.

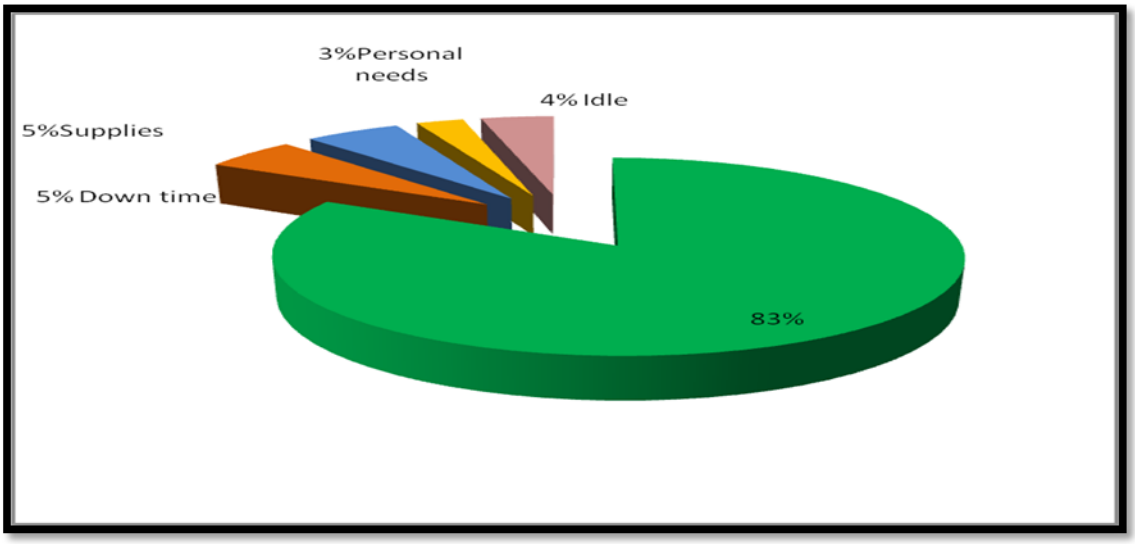

Fig 7: Packaging Section Observations at machine 2

V. DISCUSSION

From the data that was collected and analyzed, the researchers were able to identify the areas for productivity improvement. The areas were the broiler, straining and fermentation section. Using work sampling, worker and machine working time was separated from the idle time and the reasons for the idleness have been indicated in the figures shown above.

The researchers identified the causes to idle or ineffective time. Poor material handling devices and the position of the coal banker from the boiler, which is about 10 meters away contributed to ineffective time and poor workmanship in the boiler section. In addition, manual loading of the coal in the boiler by one worker also resulted in ineffective time at the boiler section. During work study, it was observed that, workers fell asleep especially during night shifts and this resulted in the reduction of the temperature at the boiler consequently affecting the required steam pressure of 5-7 bars transferred to the cooker and therefore affecting the duration of the brewing process.
The Work study also showed that the straining of the porridge exceeded the standard time of 2 hours. During the cooling stage in the fermentation process, it was observed that the process took longer than the standard hours of 6 hours. This was attributed to idle time of workers as a result of not following the standard time of each activity.

VI. CONCLUSION

Out of the 75 observations conducted at the boiler, brewing and packaging sections, the researchers concluded that; for the boiler section, 68% of the time the workers were working while the remaining 32% was attributed to ineffective time. For the brewing section, 60% of the time the workers were working while 40% was attributed to ineffective time. For the packaging section (machine 1), 80% of the time, the workers were working while 20% accounted for ineffective time. Lastly for the packaging section (machine 2) 83% of the time, the workers were working while 17% accounted for ineffective time. The researchers were able to conclude that, the difference in the results from each section is as a result of the conditions varying to a high extent from one situation to another [4]. Further the results differ from the results reviewed in literature because of the nature of the difference in the context of the two environments. Although the results are different, [4] advises that these results from work sampling studies are of high relevance for discussions on improvement opportunities among workers as well as among corporate managers. The researchers therefore made recommendations in order to improve the current methods of working in the identified areas.

VII. RECOMMENDATIONS

The researchers successfully conducted work study and therefore recommended the following.

- The coal banker to be moved closer to the boiler and/or another worker should be assigned to the boiler so that one does the transportation and another one to concentrate on loading the coal in the boiler hopper or automate the boiler system.
- Employee training especially on productivity improvement programs should be invested in so as to enhance worker skills and knowledge as most of the general workers lacked the knowledge on productivity.
- The 2 working shifts which run from 06:00-18:00hrs while another shift starts from 18:00hrs-06:00hrs the following day, the researchers recommended that the working hours be reduced by introducing a 3rd shift. The current 12 hour working shift had proved to be ineffective as workers are affected by fatigue which in-turn affects worker productivity and quality of the product.
- It was observed that the company had a shortage of crates, and at times packaging was forced to stop in order to wait for the empty crates that were in distribution to come back and this created unnecessary idle time of both the workers and the machines in the packaging section. The researcher recommended that more packaging crates be procured or the system of retention of crates be considered for improvement.
- Power interruption affected the company operations and bigger generators or solar energy were recommended.
- Increase in manpower in the packaging section was recommended as there was a shortage of workers to do the packing and this had forced the company to only use 2 packaging machines instead of 3.

Acknowledgment

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