Productivity Improvement through Work Study Techniques: A Case of a Modern Rice Mill in Ikwo, Ebonyi State

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Authors’ contributions

This work was carried out in collaboration between both authors. Author IN designed the study and did the study conceptualization. Authors IN and JEA collected and analyzed the data, interpreted the results and prepared first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To explore the use of the work-study techniques in the efficiency improvement in the productivity of a firm or industry. A firm’s profit can be increased through productivity improvement by reducing non-value-added operations and adopting a new process for a particular activity.

Study Design: Currently, productivity improvement is a crucial factor in industries. Therefore, one of the primary goals of this firm is to improve productivity which enhances its long-run profit. The most critical tool for enhancing the firm’s productivity is work study. Hence, this study noted the bottleneck and provided an appropriate technique for productivity improvement.

Place and Duration of Study: A modern rice mill in Ikwo Ebonyi State Nigeria, between March 2021 and October 2022.

Methodology: A method study was carried out using well-designed questionnaire techniques with interconnected critical analysis of a particular production line. A reasonable work content reduction

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was obtained when the proposed improvement method was applied. A stopwatch was used to obtain the time study with much emphasis on the standard time for the operation sequences. As a result, each workstation capacity per day was calculated.

**Results:** The result shows that the firm productivity index improved by 14.29% when method study and work measurement were applied in the production line. Implementation of the proposed production line improved productivity from the old production line by 14.29%. Previously, the work content per ton was 4892 mins. Considering the line balancing and critical analysis of the proposed technique, the proposed work content took 3649 mins to be completed, this leads to a reduction of work content by 1243 mins after the line balancing and analysis. The proposed method helps to increase productivity to 14.29% with 25.41% reduction of work content and line balancing.

**Conclusion:** In the Ikwo modern rice mill, productivity improvement is considered a critical factor for increasing the profit margin. Therefore, an increase in the profitable index of the firm is the function of productivity improvement, as a result of proper planning and control of the available input variables.

**Keywords:** Production; productivity improvement; work study; method study; work measurement.

### 1. INTRODUCTION

Production is any method or technique established to transform a certain set of input into a unique set of output in the right quantities and quality while achieving an industry’s goals. Through the transformation of raw materials, production facilities the development of finished goods [1]. The systematic diagram of a typical rice mill production system is shown in Fig. 1.

Productivity is defined as the ratio of the value produced to the resources needed for the production [2]. A productivity index is typically calculated as a component of productivity measurement used to compare output quantities with input resources [2,3]. Thus,

\[
Productivity = \frac{Output}{Input}
\]  

(1)

Productivity is used to determine the quantities of output products produced from a given quantity of input materials [4]. Currently, productivity measurement is a critical factor in industries. It is important to note that, the profit enhancement of any firm is a function of its productivity improvement with respect to the input variables. The reduction of non-value-added processes and other bottlenecks in a production cycle helps to improve productivity and facilitates customer satisfaction [5], [6] Noted the correlation between the productivity and output and material utilization techniques, output prices, inventory management, and distribution time. Profit increase is a result of productivity improvement [7].

Elimination of wastes, process repair, techniques modification, process simulation, minimization of input variables, and increase in output quality and decrease in set-up-time are other ways to increase a firm’s productivity. An increase in the quantity of value-added processes brings about an increase in productivity [8].

Baines A, Hamid TKA and Maloney WF [3,9,10] Noted that productivity could be improved if production cost per unit and labour cost are reduced with proper balancing of the production line [3,11]. Defined productivity as the method of improving production at a constant production rate. This study x-ray the application of the work-study technique in a production line of Ikwo modern rice mill to enhance the firm productivity. Increased profit and effective labour utilization in a firm can be obtained when improved productivity is achieved via work study [6].

The main focus of this study is to determine how Ikwo modern rice mill can improve its productivity by applying the work-study technique. A critical management model for increasing productivity is work study. It deals with men, work methods, and performance efficiency of a firm. For a firm to survive in a competitive environment depends on the use of modern technology and economic manufacturing processes [12]. Effective utilization of the machine, man, capital, and energy, helps to improve production efficiency. Proper implementation of work-study, with much emphasis on method analysis and performance evaluation, aids in improving production efficiency. To achieve the same or greater efficiency at a reduced cost, work is divided into smaller units, studied, and redesigned. [13] Classified Work study is a methodology that integrates method study and works measurement techniques to ensure the proper allocation of men and material resources while producing a specific product.
It is a managerial function with a focus on method study and work measurement that is used to determine labour efficiency and to investigate all the available resources that have a direct impact on the economy and increase production efficiency.

According to [13], the goal of work-study is to reduce costs by either planning the work for maximum productivity or increasing the productivity of the current work by making changes in existing processes through the elimination of non-value-added processes. As a result, it leads to a direct method of increasing productivity.

Consequently, it can be considered to be a practical method of increasing productivity. Work study has a close connection to productivity advancement since it is widely used to enhance the production capacity from a given set of resources with little to no additional capital investment [13].

Glossary BS [14] Stated that work-study is a practical methodology, specifically method study and work measurement used to determine the labour efficiency and to evaluate all the input variables that affect the effectiveness and economy of the existing problems under review in order to improve productivity. This shows that work-study is a direct method of increasing or enhancing productivity as a result of its capability to analyze human labor, which influences efficiency, as well as production improvement.

Nkwor CA and Nnanna I [15] Suggest that productivity and work-study are correlated as a tool to increase profitability. It is widely utilized to increase output while requiring little to no more input from a given set of resources. Several factors, including labor, material, land, machines, capital, technology, product, and management, have a direct impact on a firm’s productivity and profitability.

Md. Abdul M [16] Noted that for productivity improvement to take place in any company, the workers need to work within their limits to enhance balancing in the production line.

Akkoni PR et al. [17] Suggested that improvement in productivity can also be achieved through effective utilization of available capital, labour, material and modern machines.

Chauhan M et al. [18] Examined increase in productivity through delivery of products to the customers at the right time and right quantity.

Shantideo G, Manish RM [19] Reviewed Productivity increase by means of a work study using manufacturing industry as the area of interest.

Innovative processes and the installation of modern machinery are two effective long-term productivity drivers. But a significant amount of funds is needed for this operation. Additionally, attempts to increase productivity through the use of modern technology may have an impact on initiative to increase job opportunities.

The goal of work study, on the other hand, is to increase productivity by objectively analyzing the current operations, processes, and work practices in order to increase their efficiency with little to no additional capital expenditure. It is necessary to use work study effectively and throughout the production processes in order to achieve productivity improvement. As a result, the International Labour Organization has demonstrated the correlation between work study and increased productivity.

This conceptual diagram is used to analyze the production line using a specific set of products. We chose the Ikow modern rice mill for this study to analytically evaluate its existing methods and time study with a stopwatch. We compute the standard time from the observed time for each operation, while the performance rate of the workers was computed using a rating system and two forms of allowance. The goal of this study is to increase productivity by analyzing the firm's manufacturing process using the work study approach. Identifying current production problems and devising new approaches via technical evaluation.

Fig. 1. Production system [1]
2. MATERIALS AND METHODS

In order to reduce the work content of the selected product, we adopted step by step procedure to achieve productivity improvement through work study method. To achieve the stated goal we developed a conceptual framework for the study, we first selected Ikwo rice mill to the study its production line. All the operations in the production line were observed with the help of stopwatch. At the point of observing the operation the existing problem was identified through questioning technique. After that a new method or process for the product was developed. The practical application of the new proposed method in a particular production line showed that the productivity has been improved.

The following tools were employed to enable us collect and analyzed the data collected for the study. These include:

2.1 Time Observed

Duran C, Cetindere A and Aksu YE [20] Defined it as the time taken to carry out a single operation or series of operations, which can be determined through direct measurement.

2.2 Time Considered

The time chosen as being representative of a group of times for an operations or group of work by calculating mean, median or mode.

2.3 Rating

This is used to evaluate the worker’s productivity in relation to the researcher’s perception based on the method employed. [21] Presented the widely accepted rating system as presented in Table 1.

2.4 Basic Time

This is the minimum time needed to produce a unit output from available input resources. According to [21] it is the time required to perform some activity at a given specification or standard.

\[
\text{Basic Time} = \frac{\text{Observed Time} \times \text{Observed Rating}}{\text{Standard Rating}}
\]  

(2)

2.5 Standard Time

This is a job cycle time at a standard performance (Time needed to complete on operation) [21].

\[
\text{Standard Time} = \text{Basic time} + \text{Allowances}
\]

(3)

In this study, 15% and 3% relaxation and contingency allowances respectively were considered.

2.6 Relaxation Allowance

This is the important aspect of the time that can be added to the basic time to determine the standard time to produce a particular product. Allowances given to a worker depend upon the type of job performed. 15% of the basic time was generally accepted as a relaxation allowance added to determine standard time [22].

2.7 Contingency Allowance

This is the minimum time estimated while planning for unexpected production activities. This time should added to the basic time to determine the standard time for time studies [22]. 3% contingency was chosen for our study.

\[
\text{Efficiency} = \frac{\text{Present Output}}{\text{Standard Capacity}}
\]

(4)

Increasing Efficiency = \[
\frac{\text{(The efficiency of proposed line} \times \text{Present efficiency})}{\text{Present efficiency}} \times 100
\]

(5)

% of work content reduction per ton

\[
= \left( \frac{\text{Present work content/ton} - \text{Proposed content/ton}}{\text{Present work content/bag}} \right) \times 100
\]

(6)

Increasing productivity at (100% capacity)

\[
= \left( \frac{\text{Proposed Standard output} - \text{Existing output}}{\text{Existing output}} \right) \times 100
\]

(7)
Table 1. Rating system [21]

<table>
<thead>
<tr>
<th>Rating (%)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0</td>
<td>Zero Activity</td>
</tr>
<tr>
<td>Up to 50</td>
<td>Operations too slow, loss of interest to perform jobs</td>
</tr>
<tr>
<td>Up to 75</td>
<td>No compromised performance while on job, No waste of time, effective supervision of the workers</td>
</tr>
<tr>
<td>Up to 100</td>
<td>Serious business orientation, use of skilled labourers, standard quality and right production rate</td>
</tr>
<tr>
<td>Up to 125</td>
<td>Operators show interest, fast moving operations, under well-coordinated materials flow</td>
</tr>
<tr>
<td>≥ 150</td>
<td>Little or no supervision, exceptional performance by outstanding workers</td>
</tr>
</tbody>
</table>

3. COLLECTED DATA AND ANALYSIS

In order to achieve our research objective practically, a modern rice mill Ikwo was selected for real-life implementation. On milled rice, observation was done on each production line with respect to time study. We observed that 18 operations were involved in a complete production cycle. Based on this, we observed and computed time for the 18 operations with the aid of a stopwatch. In each operation, five observed times were taken to determine the time for an operation to be completed. From the data obtained, the basic times were calculated using a specific rating point for a worker as stated in equation (2). Equation (3) was used to calculate the standard time including relaxation and contingency allowances. Based on this, standard time of 8 hours working time were considered for each worker.

Fig. 3 showed the flow chart of the existing production line.

3.1 Analysis of Data

3.1.1 Proposed production line for the firm

We observed a significant improvement on some of the identified problem while implanting the proposed techniques on the existing operations. We did some important operations to improve the productivity of the selected product. In Table 3 the vital activities carried out while implementing our research approach were presented.

Table 4 showed the operations and time analysis of the proposed production line balancing.

Fig. 4 showed the flow chart of the proposed production line.
Table 2. Existing operations in Ikwo rice mill in minutes

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Name of the operations</th>
<th>Observed times in minutes</th>
<th>Selected Time</th>
<th>Rating</th>
<th>Basic Time</th>
<th>Standard Time</th>
<th>Manual or m/c</th>
<th>Man power</th>
<th>Capacity/Day@100% efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Loading &amp; off load of paddy</td>
<td>566 560 490 545 550</td>
<td>542</td>
<td>80</td>
<td>434</td>
<td>512</td>
<td>Manual</td>
<td>6</td>
<td>857</td>
</tr>
<tr>
<td>2</td>
<td>Steam heating of paddy</td>
<td>273 262 279 269 275</td>
<td>271</td>
<td>80</td>
<td>217</td>
<td>295</td>
<td>Manual</td>
<td>5</td>
<td>563</td>
</tr>
<tr>
<td>3</td>
<td>Drenching</td>
<td>108 118 120 111 115</td>
<td>114</td>
<td>80</td>
<td>91</td>
<td>169</td>
<td>Manual</td>
<td>4</td>
<td>897</td>
</tr>
<tr>
<td>4</td>
<td>Soaking</td>
<td>330 370 340 290 350</td>
<td>340</td>
<td>80</td>
<td>272</td>
<td>380</td>
<td>Manual</td>
<td>6</td>
<td>1500</td>
</tr>
<tr>
<td>5</td>
<td>Clearing</td>
<td>240 250 235 246 238</td>
<td>242</td>
<td>85</td>
<td>206</td>
<td>284</td>
<td>Manual</td>
<td>8</td>
<td>592</td>
</tr>
<tr>
<td>6</td>
<td>Drying</td>
<td>400 370 320 420 350</td>
<td>370</td>
<td>80</td>
<td>296</td>
<td>374</td>
<td>Sun</td>
<td>10</td>
<td>1371</td>
</tr>
<tr>
<td>7</td>
<td>Inspection</td>
<td>105 110 100 120 118</td>
<td>111</td>
<td>85</td>
<td>94</td>
<td>172</td>
<td>Manual</td>
<td>3</td>
<td>873</td>
</tr>
<tr>
<td>8</td>
<td>Husking</td>
<td>250 225 240 255 228</td>
<td>240</td>
<td>80</td>
<td>192</td>
<td>270</td>
<td>M/c</td>
<td>4</td>
<td>527</td>
</tr>
<tr>
<td>9</td>
<td>Polishing</td>
<td>220 230 270 190 250</td>
<td>230</td>
<td>80</td>
<td>184</td>
<td>262</td>
<td>M/c</td>
<td>6</td>
<td>2286</td>
</tr>
<tr>
<td>10</td>
<td>Milling</td>
<td>230 221 225 235 218</td>
<td>225</td>
<td>80</td>
<td>180</td>
<td>258</td>
<td>M/c</td>
<td>7</td>
<td>453</td>
</tr>
<tr>
<td>11</td>
<td>Destoning</td>
<td>208 230 220 227 223</td>
<td>223</td>
<td>80</td>
<td>178</td>
<td>256</td>
<td>M/c</td>
<td>4</td>
<td>457</td>
</tr>
<tr>
<td>12</td>
<td>Whitening</td>
<td>188 192 180 178 185</td>
<td>185</td>
<td>85</td>
<td>157</td>
<td>235</td>
<td>M/c</td>
<td>2</td>
<td>519</td>
</tr>
<tr>
<td>13</td>
<td>Length Grading</td>
<td>450 400 420 440 390</td>
<td>420</td>
<td>80</td>
<td>336</td>
<td>414</td>
<td>Manual</td>
<td>2</td>
<td>1200</td>
</tr>
<tr>
<td>14</td>
<td>Inspection</td>
<td>112 101 99 114 108</td>
<td>107</td>
<td>85</td>
<td>91</td>
<td>169</td>
<td>Manual</td>
<td>2</td>
<td>449</td>
</tr>
<tr>
<td>15</td>
<td>Shifting</td>
<td>129 126 123 139 138</td>
<td>131</td>
<td>85</td>
<td>111</td>
<td>189</td>
<td>Manual</td>
<td>6</td>
<td>733</td>
</tr>
<tr>
<td>16</td>
<td>Blending</td>
<td>259 275 250 265 269</td>
<td>263</td>
<td>85</td>
<td>224</td>
<td>302</td>
<td>Manual</td>
<td>4</td>
<td>727</td>
</tr>
<tr>
<td>17</td>
<td>Final Inspection</td>
<td>58 65 60 67 60</td>
<td>62</td>
<td>85</td>
<td>53</td>
<td>131</td>
<td>Manual</td>
<td>2</td>
<td>1524</td>
</tr>
<tr>
<td>18</td>
<td>Weighing &amp; Bagging</td>
<td>177 170 167 188 185</td>
<td>177</td>
<td>80</td>
<td>142</td>
<td>220</td>
<td>Manual</td>
<td>12</td>
<td>857</td>
</tr>
</tbody>
</table>

|               | 3258 | 4892 | 93  |
4. RESULTS AND DISCUSSION

The firm documents showed that the existing production line has a production capacity of 1050 bags of 50 kg per day. The firm has 8 hours working days. It also showed that the total number of workers on the same production line is 93 persons, therefore, following equation (1), the production line has mean production capacity of about 52.5 tons per day. The total operating time on the production line was 480 mins as recorded, then when equation (3) is applied the standard time per day (present work content) obtained was 4892 mins and 93.18 mins as the standard time per ton.

The documents showed that the firm standard production capacity under 100% efficiency was 175 tons per day. When equation (4) is applied 30% efficiency was obtained. This efficiency value showed that the existing production line operates low production capacity, with a direct impact on the productivity of the firm.

The present work content per ton was 4892 mins. Considering the line balancing and critical analysis of the proposed technique, the proposed work content took 3649 mins to be completed, this leads to a reduction of work content by 1243 mins after the line balancing and analysis. This represents 25.41% of work content reduction per ton.
The proposed production line under the standard production efficiency of 100% produced 200 tons per day. Then the daily output for the existing standard production line was 175 tons. When equation (7) was applied, 14.29% increase in productivity was obtained.

In this study, implementation of the proposed production line improved productivity from the existing production line by 14.29%. Our new approach, which includes balancing of production line and reduction in job content improved productivity by 14.29%. Our proposed method helps to increase productivity to 14.29% with 25.41% reduction of work content and line balancing.

Table 3. Critical analysis of operation

<table>
<thead>
<tr>
<th>Operation</th>
<th>Existing Line</th>
<th>Proposed Line</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing method</td>
<td>Standard Time/ton</td>
</tr>
<tr>
<td>Cleaning of paddy</td>
<td>Removing all impurities and unfilled grains from the paddy is generally done using a single screen bed oscillating. This usual need more time.</td>
<td>284</td>
</tr>
<tr>
<td>Husking</td>
<td>Removing the husk from the paddy is generally done using Steel husker. The using Steel husker for husking need more time. It has low milling efficiency and produces high amount of cracked and broken rice.</td>
<td>270</td>
</tr>
<tr>
<td>De-stoning</td>
<td>Separating small stones from the brown rice is done manually. The using of manual method to separate stones from rice need more time.</td>
<td>256</td>
</tr>
<tr>
<td>Inspection</td>
<td>Inspection is done in de-stoning.</td>
<td>172</td>
</tr>
<tr>
<td>Polishing</td>
<td>Improving the appearance of milled rice by removing remaining bran particles and by polishing the exterior of the milled kernel. This is done using friction – friction – polishing. This method need more time than a mist method.</td>
<td>262</td>
</tr>
<tr>
<td>Weighing and bagging</td>
<td>Preparing milled rice for transport to the customer. This is done using bags, filled manually and closed by the bag stitchers. Due to the nature of the top, it need more skilled worker and more time.</td>
<td>220</td>
</tr>
</tbody>
</table>
Table 4. Production line balancing as proposed for Ikwo rice mill

<table>
<thead>
<tr>
<th>S/No</th>
<th>Operation</th>
<th>Time observed (mins)</th>
<th>Rating (%)</th>
<th>Basic Time (mins)</th>
<th>Standard Time (mins)</th>
<th>Machine or Manual</th>
<th>Labour capacity</th>
<th>Production capacity per day @ 100% efficiency</th>
<th>Production capacity per day @ 85% efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Loading &amp; off load of paddy</td>
<td>542</td>
<td>80</td>
<td>434</td>
<td>512</td>
<td>Manual</td>
<td>6</td>
<td>281</td>
<td>2390</td>
</tr>
<tr>
<td>2</td>
<td>Steam heating of paddy</td>
<td>107</td>
<td>80</td>
<td>86</td>
<td>164</td>
<td>Machine</td>
<td>2</td>
<td>763</td>
<td>590</td>
</tr>
<tr>
<td>3</td>
<td>Soaking</td>
<td>340</td>
<td>80</td>
<td>272</td>
<td>380</td>
<td>Manual</td>
<td>6</td>
<td>2880</td>
<td>1542</td>
</tr>
<tr>
<td>4</td>
<td>Clearing</td>
<td>60</td>
<td>80</td>
<td>48</td>
<td>126</td>
<td>Machine</td>
<td>3</td>
<td>700</td>
<td>595</td>
</tr>
<tr>
<td>5</td>
<td>Drying</td>
<td>80</td>
<td>80</td>
<td>64</td>
<td>142</td>
<td>Machine</td>
<td>3</td>
<td>1560</td>
<td>880</td>
</tr>
<tr>
<td>6</td>
<td>Inspection</td>
<td>120</td>
<td>85</td>
<td>102</td>
<td>180</td>
<td>Manual</td>
<td>2</td>
<td>1536</td>
<td>1056</td>
</tr>
<tr>
<td>7</td>
<td>Polishing</td>
<td>120</td>
<td>80</td>
<td>96</td>
<td>174</td>
<td>Machine</td>
<td>3</td>
<td>2800</td>
<td>1680</td>
</tr>
<tr>
<td>8</td>
<td>Husking</td>
<td>200</td>
<td>80</td>
<td>160</td>
<td>238</td>
<td>Machine</td>
<td>3</td>
<td>980</td>
<td>756</td>
</tr>
<tr>
<td>9</td>
<td>Milling</td>
<td>225</td>
<td>80</td>
<td>180</td>
<td>258</td>
<td>Machine</td>
<td>7</td>
<td>1000</td>
<td>920</td>
</tr>
<tr>
<td>10</td>
<td>Destoning</td>
<td>107</td>
<td>80</td>
<td>86</td>
<td>164</td>
<td>Machine</td>
<td>2</td>
<td>690</td>
<td>580</td>
</tr>
<tr>
<td>11</td>
<td>Whitening</td>
<td>185</td>
<td>85</td>
<td>157</td>
<td>235</td>
<td>Machine</td>
<td>2</td>
<td>700</td>
<td>640</td>
</tr>
<tr>
<td>12</td>
<td>Length Grading</td>
<td>110</td>
<td>85</td>
<td>94</td>
<td>172</td>
<td>Machine</td>
<td>1</td>
<td>1700</td>
<td>1400</td>
</tr>
<tr>
<td>13</td>
<td>Inspection</td>
<td>107</td>
<td>85</td>
<td>91</td>
<td>169</td>
<td>Manual</td>
<td>2</td>
<td>580</td>
<td>540</td>
</tr>
<tr>
<td>14</td>
<td>Shifting</td>
<td>60</td>
<td>80</td>
<td>48</td>
<td>126</td>
<td>Machine</td>
<td>2</td>
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5. CONCLUSION

The study has shown that in Ikwo modern rice mill, productivity improvement is considered a critical factor for increasing the profit margin. Therefore, an increase in the profitable index of the firm is the function of productivity improvement, as a result of proper planning and control of the available input variables.

The study identified the differences between processes and operations while producing an output. The study also identified how to determine the limitations of production operations and processes of producing a particular product.

Productivity improvement can be achieved by putting time and method studies into practice, as well as adopting method methodology for specific operations. Productivity improvement of a product also depends upon a proper balancing of the production line. We were unable to use this method for other products due to the time factor. For effective reduction of activities and tasks for productivity improvement, the best technique to be employed for such a goal is lean manufacturing. The study demonstrates how reducing work content and balancing the production line affect the productivity of the firm.

Finally, I recommend that further research could be on the integration of lean manufacturing and work-study technique.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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