DEVELOPMENT OF A MODEL FOR OPTIMAL UTILIZATION OF MANPOWER IN CEMENT PRODUCTION PLANNING PROCESS

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Abstract
This study introduces the development of a model and its optimal application in the utilization of manpower in cement production planning process, and the goal is to develop a model for manpower determination in cement production process in order to meet optimum production. The developed model will be particularly of great assistance to new comers who are not familiar with the field and will facilitate them in gaining a better understanding of the required manpower for production process and in making decisions about any necessary actions. The developed model is versatile in the sense that it quickly generates results, which hasten decision making process on Manpower utilization.

Keywords: cement, optimal utilization, manpower, planning process

INTRODUCTION
In recent years, concurrent engineering has emerged as a key practice in enhancing the competitiveness of a product. Most people agree that the cost and quality of a product are “locked” into the layout design. Many companies are actively pursuing means to integrate the life-cycle values of the product early in its development.

The manufacturing scene today is undergoing a revolution. Infact the technology that had the greatest impact on the production system over the last decades is computer modeling. Modeling have important role to play in job shop and batch production manufacturing plants, which constitute an important portion of the total manufacturing activity. It may be remembered that traditional batch manufacturing suffers from drawbacks like low equipment utilization, long lead times, inflexibility to market needs, increased indirect cost and high manufacture cost. It is estimated that in conventional batch production methods, only 5 to 10% time is utilized on machines and the rest is spent on moving and waiting. Out of the total time on machine, only 30% is on machining, rest being on positioning, loading, gauging and idling.

Consequently, a need exists for adequate modeling cement production process in the manufacturing sector using feedback control, process control, planning and decision making to support manufacturing activities (Jain, 2001). Market demands have changed towards higher quality, shorter delivery times and lower product cost. To be competitive, it is necessary to reduce or completely eliminate material wastage in order to keep the manufacture cost as low as possible, hence the need to model the production process of cement. The objectives of this research are to ascertain the relevant manpower parameters related to the planning of cement production process and develop a mathematical model for expert system in the planning of cement production process.

Case Study: West African Portland Cement (WAPCO)
The company used as case study is West African Portland Cement (WAPCO), the oldest cement factory in Nigeria, established in 1959 and is involved in the manufacture and wholesale of cement and building products. Major shareholders include Blue Circle of the UK, O’dua Investment Company, and the Nigerian government. WAPCO has two cement factories, both in Ogun State, precisely in Ewekoro and Shagamu, established in 1960 and 1978 respectively. The former was replaced by a new plant in 2003, and is the largest cement producer in Nigeria, with an effective annual production capacity of approximately 1 million tons (WAPCO Cement, 2010) with a workforce of about 1,750 employees in its labour force (WAPCO Cement, 2010).

Ewekoro cement factory is located in Ewekoro Local Government Area, Ogun State in southwestern Nigeria (Figure 1; Maps 1–4). The cement production facility, located about 5 km north of Ewekoro town (6°55’N, 3°12’E), lies within the tropical rainforest vegetation belt of Nigeria. The production facility is surrounded by settlements which predate the cement company. The settlements include Olapeleke and Irori to the north and Elebute Alaguntan to the east of the factory (Figure 1; Map 3). The climatic conditions prevailing over the cement production facility riparian ecosystems were mainly those of the tropical rainforest, typified by an average annual temperature of 30 ± 10°C, relative humidity of 65 ± 10% and an average annual rainfall of 1500 ± 120 mm (Oguntoyinbo et al. 1983).

Table 1: Data on Manpower Strenght for Cement Production

<table>
<thead>
<tr>
<th>Manpower Category</th>
<th>Manpower strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managerial personnel</td>
<td>12</td>
</tr>
<tr>
<td>Engineers</td>
<td>108</td>
</tr>
<tr>
<td>Operators</td>
<td>470</td>
</tr>
<tr>
<td>Casual workers</td>
<td>210</td>
</tr>
</tbody>
</table>

Source: (WAPCO Cement, 2010)
The global optimum expected number of manpower \( P_i^e \) is obtained as a measure of ratio of global capacity (tons) per day of the machine and the capacity (ton) an operator can produce per day, \( C_i^m / C_i^e \) (1)

\[
P_i^e = \frac{C_i^m}{C_i^e}
\]

Manpower savings \( P_i^{s} \) (hours of idle per day) is obtained from Eqn. 2

\[
P_i^{s} = P_i^e - P_i^{sa}
\]

where;

\( P_i^{sa} \), is the actual number of manpower at the operators’ level.

The manpower quantity at operators’ level \( P_i^e \) will determine the (expected) requirements for other levels of managerial manpower, \( P_i^{sa} \) based on proportionality principle stated in Eqn. 3

\[
P_i^{sa} = P_i^{s} \cdot P_i^{sa}
\]

Where \( P_i^{sa} \), is the actual manpower obtained from other levels of manpower in the cement processing plant.

**Modeling Cement Production Processes**

The identified critical elements of cement production includes: the proportion of materials used for cement production; proportion of energy used for the production; capacity of the machines used for cement production and manpower required for the operations. To determine the Manpower Utilization, the other factor required like Machine and Material Capacity must be determined because they work vis-à-vis. It’s based on the result obtained that will assist to determine the Manpower requirement to perform in each of the section in the production process. But for the purpose of this study, effort will be concentrated on the optimal utilization of manpower development using a model.

**Capacity Determination Per Tonne of Processed Cement**

Based on the process parameters’ ratio given in Table 3, the expected capacity (in tonnes) of material required for cement production is obtained. For crusher capacity of 2500 tonnes per day (Table 3). CL- crushed limestone from limestone crusher of capacity, CL 2500tons per day and the crushed limestone and cement output ratio expressed as

\[
\frac{CL}{C_e} = 1.4675062622
\]

(4)

the maximum (expected) tonnage of cement to produce from the input material from the crusher CL is \( C_e^{CL} \) per day

\[
C_e^{CL} = \frac{2500}{1.4675062622} = 1703.5702432
\]

(5)

Similarly for raw mill of actual capacity of 3000 tonnes will produce, \( C_e^{RM} \) per day

\[
C_e^{RM} = \frac{3000}{12760.924019} = 2350.9269956 \text{Tons/day}
\]

(6)

Kiln hosts the cake/clinker with capacity (in tonnes) per day of 3500 will also produce output cement of \( C_e^{KC} \) tonnes per day. That is,

\[
C_e^{KC} = \frac{3500}{0.917} = 3816.7938931 \text{tons/day}
\]

(7)

From the expected capacity results presented before, it is noticeable that the expected output per day from the machines except kiln cannot satisfy the actual cement mill capacity. Therefore, compensation will be required to attain maximum daily actual capacity of cement mill of 2700 tones per day. Hence, there will be a limit to the output capacity depending on the expected capacity of the processing machines. However from the former capacity analyses, the minimum (expected) possible output of cement that will prevent wastage is estimated as 1703.57402432 tonnes per day. The useful time (hr) per day of operation of the whole plant based on the minimum possible output with zero waste tolerance for the cement production machines need to be adjusted to meet the expected output called economic output. This can be obtained by using proportionality concept which is based on the ratio of expected machine capacity and the actual machine capacity as expressed in the aforesated mathematical model. The result is shown in Table 2

\[
\text{Expected hr/day} = \frac{\text{expected capacity}}{\text{actual capacity}} \times \text{[actual (hr)/day]}
\]

(8)

<table>
<thead>
<tr>
<th>Machines</th>
<th>Capacity (actual) tonnes</th>
<th>Actual time (hr/day) tonnes</th>
<th>Capacity (expected) tonnes</th>
<th>Expected time (hr/day) tonnes</th>
<th>Savings in mill tonnes</th>
<th>6hrs miller/day</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone Crusher</td>
<td>2500</td>
<td>18</td>
<td>1704</td>
<td>12.2688</td>
<td>5.73</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Raw Mill</td>
<td>3000</td>
<td>18</td>
<td>1704</td>
<td>10.2244</td>
<td>7.78</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Kiln</td>
<td>3500</td>
<td>19</td>
<td>1704</td>
<td>9.2502857153</td>
<td>9.75</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Cement Mill</td>
<td>2700</td>
<td>16</td>
<td>1704</td>
<td>10.0977777778</td>
<td>5.90</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Packaging Machine</td>
<td>3333</td>
<td>14</td>
<td>1704</td>
<td>7.15755555514</td>
<td>6.84</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Total=10

211
From Table 2 it can be seen that the cement production value per worker is $21704 \div 2$ tonnes, which is 852 tonnes per worker (operator). Invariably it is noticeable that only two operators will produce the stated amount. That is

\[
\text{NumberOfOperator} = \frac{852 \text{ tonnes}}{\text{Operator}}
\]

(9)

Similarly,

\[
\text{NumberOfOperator} = \frac{\text{ExpectedManhourOperator}}{\text{ManhourAvailable / Operator}}
\]

(10)

The savings in manpower/man-hour are also stated. It can be seen that not less than 33.3% man-hour was saved per tonne of the processed cement on the basis of 6 hour per day per operator analysis.

Table 3: Savings Results on Manpower Strength for the Entire Plant

<table>
<thead>
<tr>
<th>Category</th>
<th>Actual Strength (WAPCO)</th>
<th>Expected Strength (Model Developed)</th>
<th>Savings Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managerial personnel</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Engineers</td>
<td>108</td>
<td>72</td>
<td>36</td>
</tr>
<tr>
<td>Operators</td>
<td>470</td>
<td>314</td>
<td>156</td>
</tr>
<tr>
<td>Casual workers</td>
<td>210</td>
<td>140</td>
<td>70</td>
</tr>
</tbody>
</table>

Expert system would assist tremendously in the synchronisation and effective planning of the cement production process in order to avoid these wastage of manpower. This development will bring about savings in additional cost of procuring unsuable resources in the cement production process. Savings in manufacturing cost of cement will definitely reduce the price per tonne of processed cement in Nigeria.

The developed model has helped to identify and ascertain the right proportion of the requirements of manpower and parameters related to the cement production process and have proved to be very consistent in its decision making process during verification of its results by using test cases, based on relevant data collected from the case study, Ewekoro cement company.

**BIOGRAPHY**

Engr. Dr. Ogbeide Samson is happily married with Children. He is a Senior Lecturer in the Mechanical Engineering Department of Ambrose Alli University, Ekpoma, Edo State, Nigeria. He has published several papers with both International and Local Journal.

**REFERENCES**


APPENDIX