Impact of the Adoption of Computer Aided Process Planning (CAPP) Software Package for Small Scale Bottled Water Industry in Nigeria.

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ABSTRACT

The adoption of appropriate technology is key to achieving optimal production process in any manufacturing environment. This paper describe the adoption of an interactive software package developed in the Visual Basic.6.0 2006 environment, and Microsoft Office Access 2007 as database for the management of production process planning in small scale bottled water industry in Nigeria. The software presented an optimum process plan in quick and consistent fashion which is one of the objectives of Computer Aided Process Planning (CAPP).

(Keywords: computer aided process planning, appropriate technology, simulation, small scale bottled water industry and Nigeria.)

INTRODUCTION

Production process is the transformation process of raw materials into end products, usually through a series of transformation steps producing and consuming intermediate products [6]. Adoption of appropriate technology into small scale industry as called for the introduction of computer technology to aided production process planning. Computer Aided Process Planning (CAPP) is the use of computer with appropriate software to automatically plan a production process for improved productivity and optimal resource utilization [3].

This paper presents the merit of the adoption of appropriate technology in the development of a (CAPP) software package using a small scale bottled water industry as case study.

MATERIALS AND METHODS

The methodology involves a description of the bottled water production process of a small scale bottled water industry, adoption of mathematical model to model and simulate the process, and the development of the software.

Production Process Description

- The Preform Heating Stage.
- The Preform Blowing Stage.
- The Bottle washing Stage.
- The Bottle filling Stage.
- The Bottle capping Stage.
- The Bottle coding Stage.
- The Label shrinking Stage.
- The Bottled water packing Stage.

A- Bottle production process
B- Bottled water production process

The above listed stages are the stages involved in the production process of bottled water in small scale bottled water industry

Mathematical Model

Two mathematical models where adopted in the development of the system to model and simulate the process. The mathematical models are as follows:

Master Production Scheduling Model

$$\min \sum_i \sum_t \{p_t^i x_t^i + f_t^i y_t^i + h_t^i s_t^i\} \quad (1)$$

$$s_{t-1}^i + x_t^i = d_t^i + s_t^i \ for \ all \ i, t \quad (2)$$

$$x_t^i \leq M y_t^i \ for \ all \ i, t \quad (3)$$

$$\sum_i a^{ik} x_t^i \leq L_t^k \text{ for all t,k} \quad (4)$$

$$x_t^i, s_t^i \geq 0, y_t^i \in \{0,1\} \ for \ all \ i, t \quad (5)$$

The Master Production Scheduling Model was used in the development of the software to model and simulate the scheduling of the production process over a specific horizon. This allows the software to present a consistent lot size over a specific horizon.

Where t = horizon period

n = end of horizon period

x_t^i = quantity of product to be produced (bottle or bottled water) to be produced at the end of the period.

y_t^i = binary variable indicating whether or not there will be production in period t

$y_t^i = 1 \, if \, x_t^i > 0$

s_t^i = inventory of bottled water at the end of period t

p_t^i = unit cost of individual raw material (preform, cap, label and packing nylon)

h_t^i = unit cost of inventory for raw material that will be required within the specified period

f_t^i = fixed production cost for the specified period.

d_t^i = demand quantity to be satisfied at the end of the process plan where $d_t^i > 0$

M = large positive Number

L_t^i = Available capacity of resources K at the start of the process plan period

a_t^i = quantity of K respectively per unit of item i produced.

Subscript i is the quantity of product whose production process is to be planed

Subscript k is the set of raw material that will be required within the period

Material Requirements Planning Model

$$\min \sum_i \sum_t \{p_t^i x_t^i + f_t^i y_t^i + h_t^i s_t^i\} \quad (6)$$

$$s_{t-1}^i + x_{t-\gamma^i}^i = [d_t^i + \sum_{j \in s(i)} r^{ij} x_t^i] + s_t^i \quad (7)$$

$$x_t^i \leq M y_t^i \ for \ all \ i, t \quad (8)$$

$$\sum_i a^{ik} x_t^i \leq L_t^k \ for \ all \ t, k \quad (9)$$

$$x_t^i, s_t^i \geq 0, y_t^i \in \{0,1\} \ for \ all \ i, t \quad (10)$$

The Material Requirements Planning Model was used to model and simulate the raw material that would be required during a process horizon. The material requirement module present the user of the system the raw material that would be require within the process period. The model considers the inventory of raw materials, thereby preventing downtime as a result of insufficient raw material. The indices, variables and data are the same as above (in the Master Production Scheduling Model), except that, for simplicity, we also use the index $j = 1, \ldots I$ to identify items. For item i, we use the additional notation $S(i)$ to represent the set of materials that are introduced during the production process, i.e. the items that are utilized when product are produced.

We always have $S(i) = \in$ and for $j \in S(i)$, we denote r^{ij} quantity of item i required to make one unit of item j. These r^{ij}, parameter *r* is used to identify the dependent demand, whereas d_t^i corresponds to the independent demand. For each item i, we denote by γ^i the lead time deliver any lot of i. More precisely, x_t^i represents the size of a production or purchase order for item i required in period *t*, and delivered in period $t + \gamma^i$.

RESULTS AND DISCUSSION

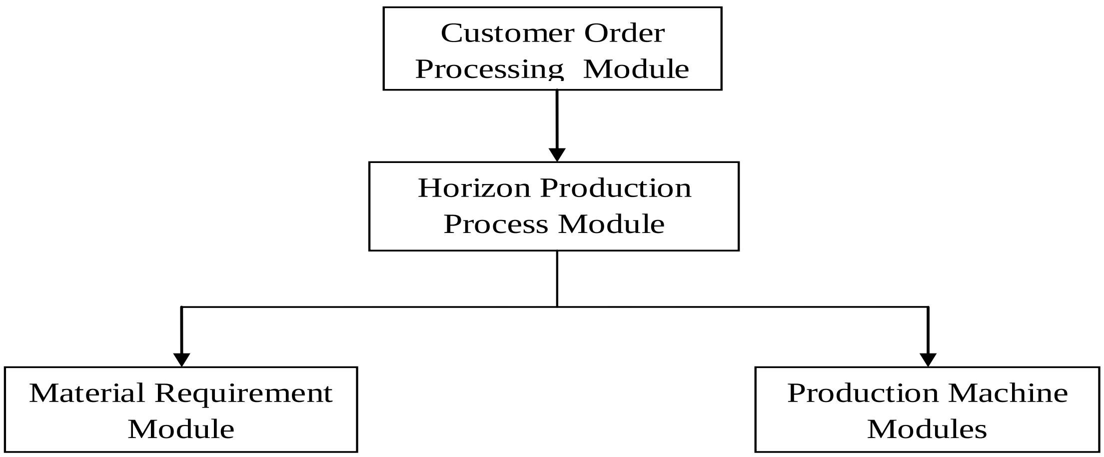

Figure 1: Developed Software Flow Diagram.

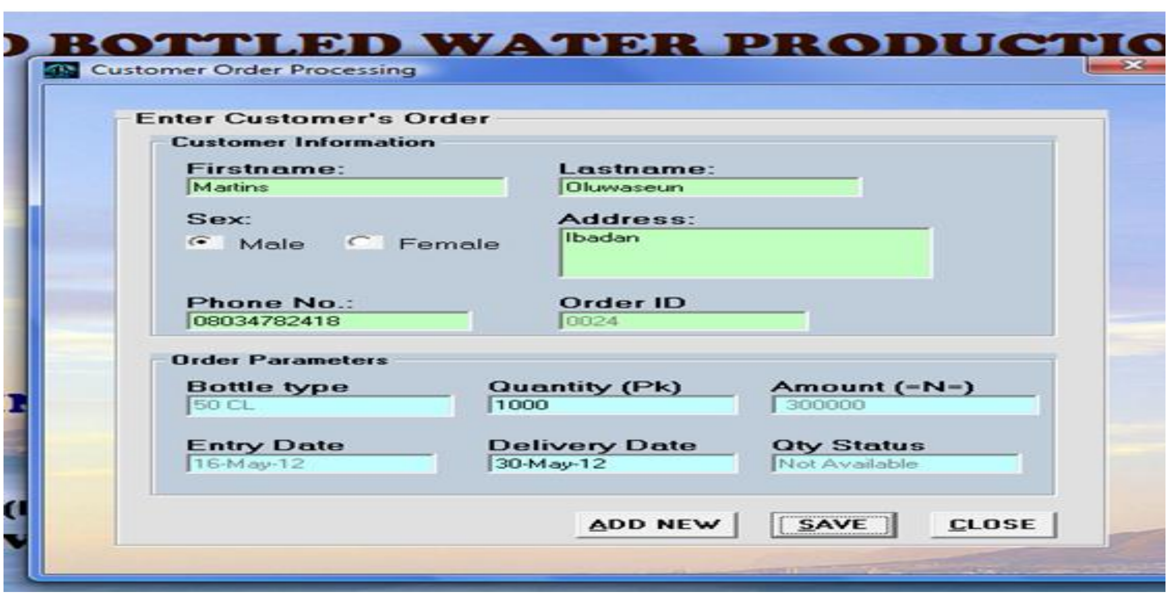

Plate 1: Customer Order Processing Module: Customer information is taken with product demand quantity. The customer information are stored in the system database. (Extracted from developed software interface).

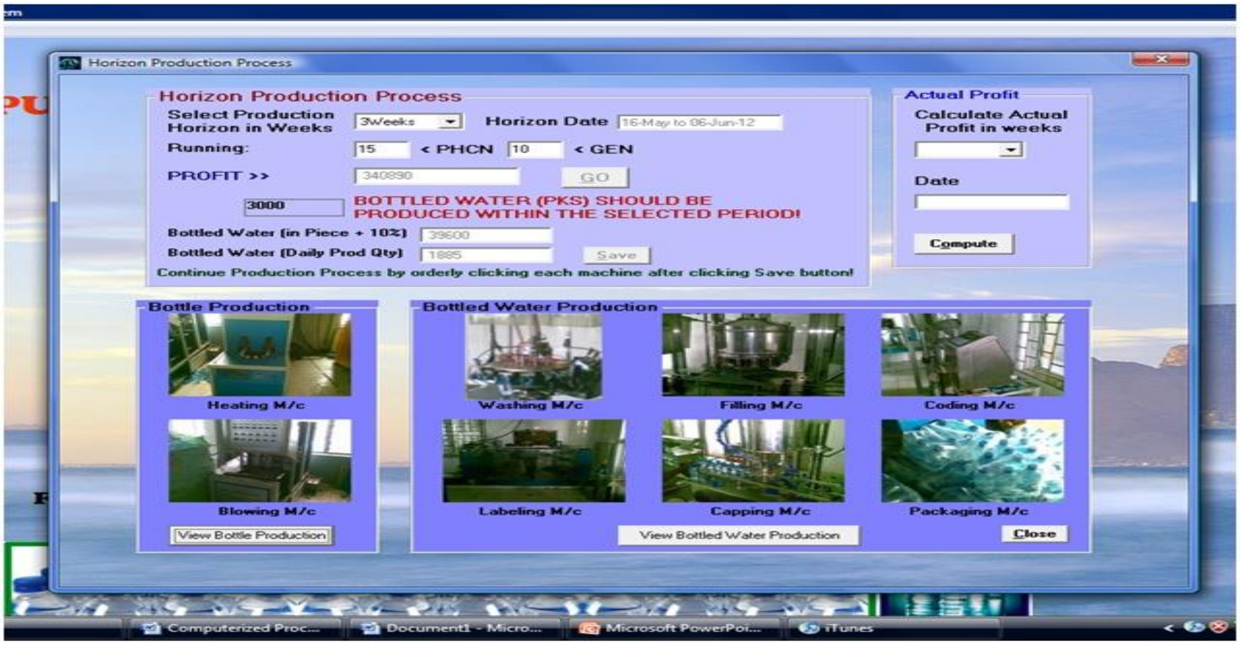

Plate 2: Horizon Production Process Module: Automatic Production Process Planning of all stored customer product demand quantity. The horizon periods are in weeks (1, 2, 3 or 4 Weeks) the developed software presenting the consistent lot size over the specified horizon period. (Extracted from developed software interface).

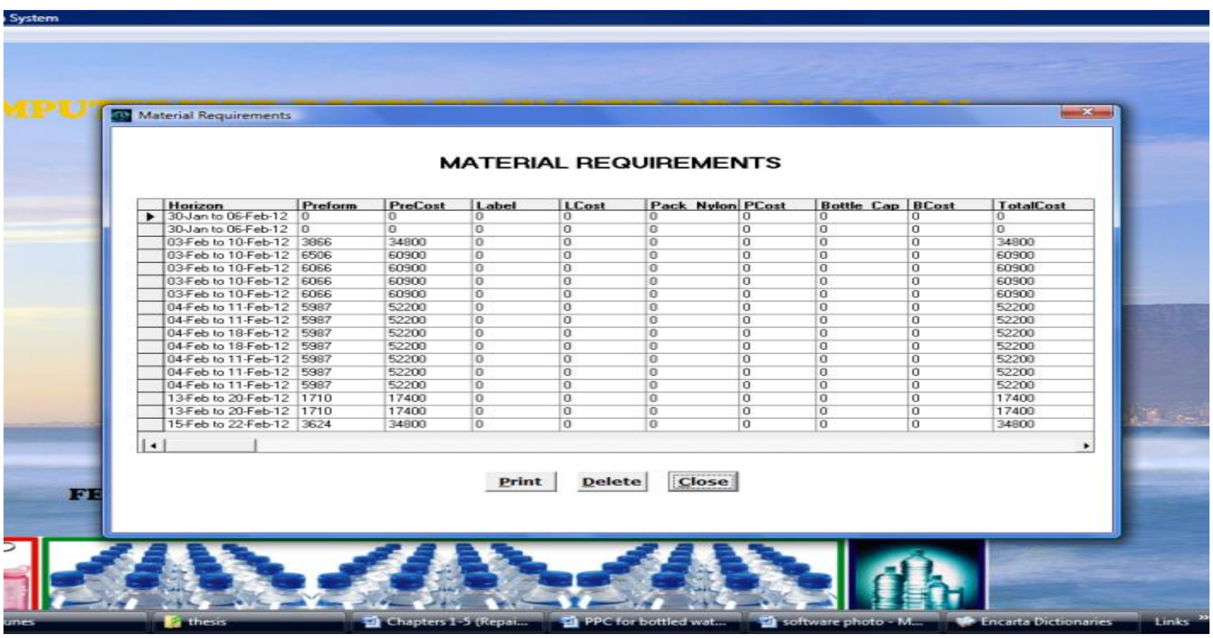

Plate 3: Material Requirement Module: Automatic Presentation of the raw material required quantity (preform, cap, label and pack nylon) and corresponding cost that would be required for the production process during the specified period of the process plan. (Extracted from developed software interface).

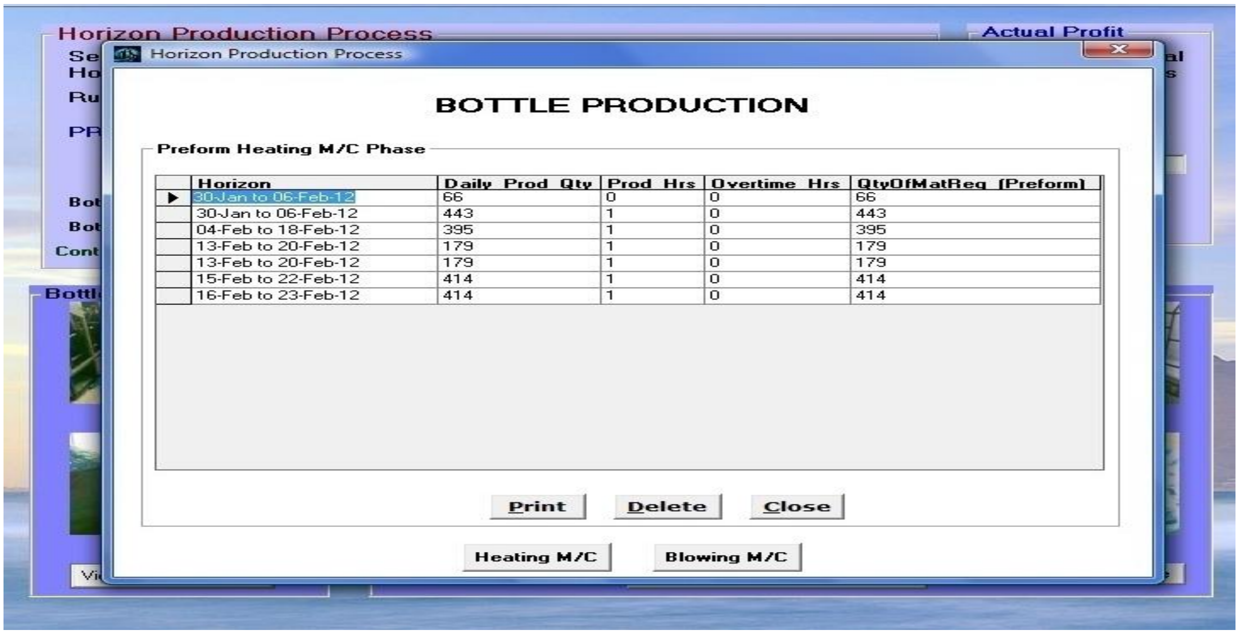

Plate 4: Bottle Production Process Machine Module: The model presents the simulated production process of the bottle production process for the specified horizon period. The two stage involved is presented their individual module. (Extracted from developed software interface).

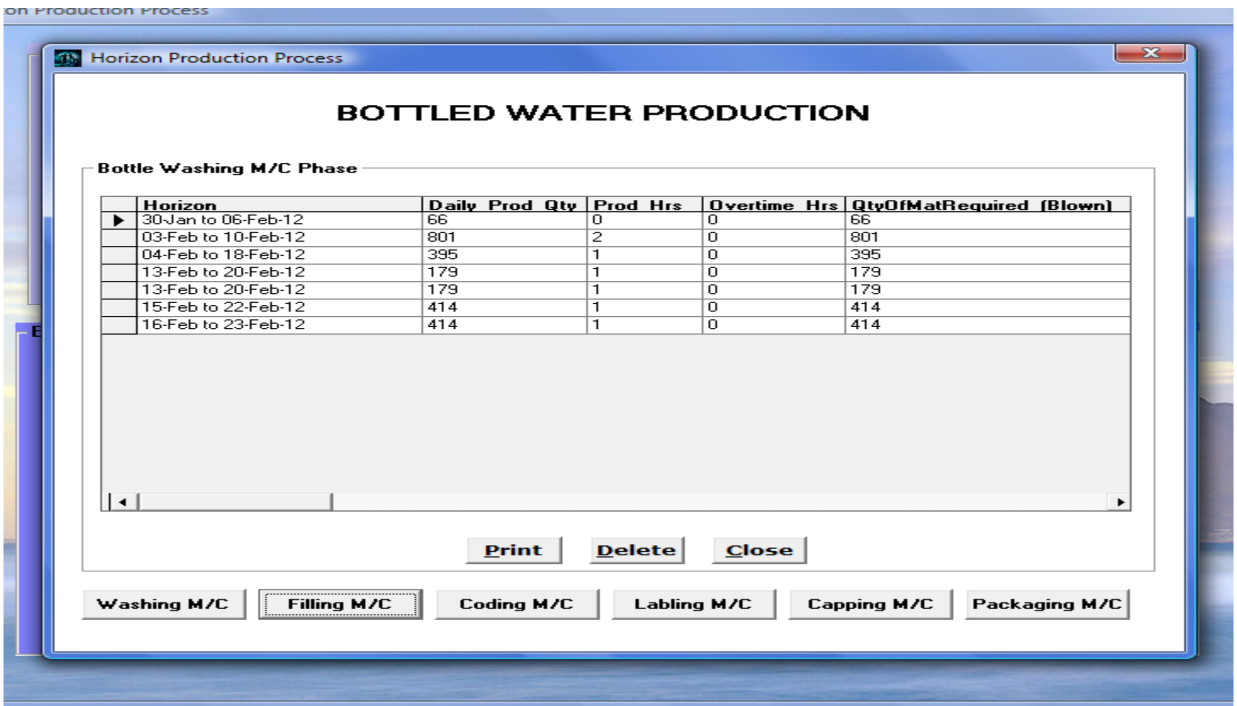

Plate 5: Bottled Water Production Process: The model presents the simulated production process of the bottled production process for the specified horizon period. The six stages involved are presented in their individual module. (Extracted from developed software interface).

Table 1: Comparison Of Real Data With Developed Data Results.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Total
Monthly Production (Packs) Real Data	1,528	1,558	1,547	1,344	1,103	1,238	1,471	1,555	1,390	1,903	1,643	1,822	**18,102**
Monthly Production (Packs) Developed System Data	1,860	1,708	1,891	1,560	1,333	1,440	1,768	1,891	1,620	2,356	1,920	2,201	**21,548**
% Increase in Quantity Produced (Packs)	***21.73***	***9.63***	***22.24***	***16.07***	***20.85***	***16.32***	***20.19***	***21.61***	***16.55***	***23.80***	***16.86***	***20.80***	***19.00***

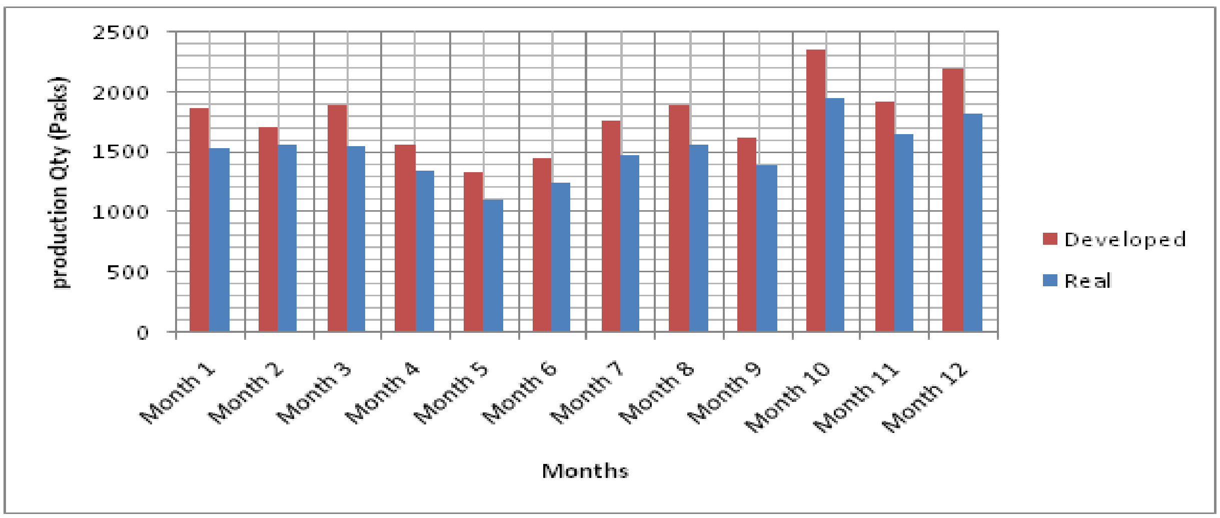

Figure 2: Comparison of Real Data with Developed Data as Presented by the Software.

The tables above present the total produced quantity for each month for a period of 12 months. The table presents the comparison of the real data that was collected from the case study industry with the developed software data for the same period. The table presents the percentage (%) increase in produced quantity for the same period, this was achieved because the developed system presented a consistent lot size over the process plan horizon. The average increase in production for each of the month is 287 packs and average production error of 8.33%, and 3,446 (19%) pack increase in production quantity.

Figure 2 shows graphical representation of the comparison of the real and developed software produced quantity within the same period.

Computer Aided Process Planning (CAPP) Software

The Computer Aided Process Planning (CAPP) Software described in this paper is called Computerized Bottled Water Production Process "CBWPP''. The software was produced from the combination of Visual Basic.6.0 2006 environment, and Microsoft Office Access 2007

Database (MADb). Visual Basic.6.0 2006 was the main programming software used while MADb was used to hold and save databases associated with the program. Each stage involved in the production process was presented in different modules.

Simulation

Simulation is the art and science of creating a representation of a process or system for the purpose of experimentation and evaluation.

The developed software described the simulation and the importance of consistent lot size towards the achievement of optimized production process over a process horizon.

Traditionally small scale industry has not been in the forefront of technological advancement in handling production process. One of the adoptions of appropriate technology into small scale manufacturing industry is the introduction of computer technology in the area of software development such as (CBWPP). Small scale manufacturing industry has over the years depended on the experience of their experienced personnel which is subjective. The developed system described in this paper automatically plans the production process of small scale bottled water industry objectively. The software also simulates the sequence of operation of each of the machines in their respective modules which are to be followed strictly in order to achieve the set objective of the process plan. The software simulates the raw material (Preform, Cap, Label, Packing nylon) requirement for the specified production process period. The software prevents production stoppages due to lack or insufficient raw material thereby improves productivity and customer satisfaction in-terms of service delivery. The software utilizes the data storage capability of the computer to hold data of all registered customers which is impossible with the human interface.

CONCLUSION AND RECOMMENDATION

In this paper, the analysis of bottled water production process of small scale bottled water industry, using a developed software called "CBWPP", was presented. The Case study presented was used to demonstrate the optimization capability of the software. It is evident that with the use of the software, presenting consistent production lot size small scale manufacturing industry can increase their production quantity and improve service delivery to their customers.

Potential increases in productivity based on optimized production process will encourage small scale manufacturing industry to increase their number of daily shift workers. Also with this system entrepreneur and financial outfit would be encourage in the setting up and investing in small scale manufacturing industry while existing industry with the use of the system will improve on their production process plan. To this end, we therefore recommend that government should adopt appropriate technology policy to small scale manufacturing sector. This will encourage small scale industry to adopt computer aided process planning software developed for their production process as this will increase their production quantity, customer satisfaction and increase employment. Also, the Engineering Council should charge engineers to develop software's such as this to handle various production process; organize training, workshops and seminars for small scale manufacturing industries so that they could have access to improved methods and technologies in the manufacturing industry.

REFERENCES

1. Abou Gamila, M. and S. Motavalli. 2003. "A Modeling Technique for Loading and Scheduling Problems in FMS". *Robotics and Computer-Integrated Manufacturing*.19(1-2):45-54.

2. Adejuyigbe, S.B. 2010. "Manufacturing and Computer Aided Engineering: A Panacea For Wealth Creation". Federal University Of Agriculture Abeokuta Nigeria Inaugural Lecture Series No. 27 delivered at 13th January, 2010. Pgs 14 – 21.

3. Atlihan, M., S. Kayaligil, and N. Erkip. 1999. "A Generic Model to Solve Tactical Planning Problems in Flexible Manufacturing Systems". *International Journal of Flexible Manufacturing Systems*. 11(3):215-243.

4. Catherine, F. 2001. "Bottled Water: Understanding a Social Phenomenon". Discussion Paper commissioned by WWF. April 2001. Pgs 6 – 21.

5. Gogg T. and J. Mott. 1993. “Introduction to Simulation”. *Proceedings of the 1993 Winter Simulation Conference*. 1993. 9–17.

6. Groover, M.P. 2000. *Automation, Production Systems, and Computer-Integrated Manufacturing*. Prentice Hall: Princeton, NJ. ISBN 0-13-088978-4, 832 p.

7. Pochet, Y. 2006. “Mathematical Programming Models and Formulations for Deterministic Production Planning Problems. CORE and IAG”. Universit´e Catholique de Louvain: Belgium 60 – 100.

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