JEAS

JOURNAL OF ENGINEERING AND APPLIED SCIENCES

Journal of Engineering and Applied Sciences, Volume 17, Number 1, June 2020, 168-187

Development and Implementation of a Computerised Production Planning and Control System

Nwamekwe C. O., Chinwuko C. E.and Mgbemena C. E*.
Industrial & Production Engineering, Department.
Nnamdi Azikiwe University Awka, Nigeria.
Corresponding Author's Email: ce.mgbemena@unizik.edu.ng Phone: +2348037582990

Abstract

To remain competitive, there is a need for production companies to maximize their profit. To achieve this, they need an automatic system that can predict future productivity based on their current production capacity, plan the materials, and schedule the production, thus the need for a Computerised Production Planning and Control System (CPPCS). This paper presents the activities carried out in the design development and implementation of a CPPCS applicable to manufacturing organisations, using a textile company in Nigeria as a case study. The system is designed to handle the forecast, material planning and scheduling of production planning and control. The design methodology adopted was the Structured System Analysis and Design Method. The design was achieved using PHP programming language and MySQL as the database file. Time series forecasting principle was adopted. The novelty of this paper is that the developed system can provide a real-time feedback on the raw material inventory and effectively schedule the product-mix. The feedback of the system was tested on two case studies and the results showed reduction in both delivery dates on customers' orders and processing time of the system. The productivity increase was calculated to be at 1.32 meters-per-unit production, and the efficiency of the system was evaluated at 79.8%. The developed system not only saves time but also produces efficient results with increased productivity.

Keywords: Product-Mix Scheduling; Real-Time Feedback; Productivity; Production Possibility Curve; Unified Modelling Language.

1. Introduction

Technical and system changes have occurred in manufacturing industries over the recent years. The requirements being placed on companies by the market have also changed. PPC responds effectively to these changes by providing a faster response and better control of resources and delivery performance. A CPPCS can effectively and efficiently provide the immediate response needed to deal with the market demands. PPC is concerned with the logistics problems that are met in manufacturing; that is, managing the details of what and how many products to produce, when and where to obtain the raw materials, and resources to produce those products (Groover, 2016).(Ozonwu, 2009) noted that in 1990 there were 175 textile factories operating in Nigeria, but today only 42 epileptic factories are operating, even as 12 of these can boast of operating at 30% capacity. Among these, 4 textile factories produce embroidery lace materials as part of their product brands". Statistically, the country's textile industry is going on extinction, hence the need for revival. The world has moved from analogue to digital, so there is an urgent need to computerise the processes of productions in manufacturing industries in order to become competitive.

A CPPCS is the integration of all the sub-functional activities involved in production planning and control into a single cohesive system (Chee, 1990). It is a software installed on the computer systems that enables a manufacturing company to achieve both material planning and PPC. It has an inbuilt system that integrates, plans, controls and manages the process of productions to the point of inventory. With the trend of technology around the world and textile industries, the computerisation of production planning and control is an essential tool to compete in the global market. If manufacturing industries in Nigeria will adopt the digital technology that is trending it will go a long way in bringing growth and stability in the country's manufacturing sector, (Onyeiwu, 1997).
The manufacturing industries do not only a critical role to play in the realisation of the Vision 2020 of the government, but also have the potential of turning the Nigeria's economy around in order to battle the unemployment monster (Amachree, 2010). Locally produced goods can go a long way in reducing the current huge

amount being spent on importation of goods(Okpugie, 2016). Product- mix also known as product assortment refers to a combination of total number of product lines a company can offer to its customers. Product-mix scheduling is the production plan of a company's product-mix(Bhasin, 2020).

1.1 Literature Review

Bagshaw (2014) opined that production schedules identify resources conflicts, control the release of jobs to the shop, and ensure that required materials are ordered in time. Lack of proper scheduling is one of the primary reasons for manufacturing firms' low productivity and weak revenues, due to low market share. In most cases, market shares mean shares of the actual sales for a product in a given period and in a given geographical area; that is, sales performance of a product class in the market, rather than a collection of buyers for the product (Hermann, 2003). However, it does not follow logically that seeking higher market share will improve profits. Rather the correlation between market share and profitability is more logically interpreted as showing that firms with better offerings tend to achieve higher market share. Conclusively, production scheduling is an important production function in realizing increased market share, profitability, productivity, reduced costs, improved product quality and increase in market share and market responsiveness resulting in satisfying the customer and improved customer relationship. (Amah *et al.*, 2014)stated that corporate productivity performance is measured in the areas of cost minimization, enhanced equity capital and growth. Production planning has significant impacts on operational efficiency, enhanced equity capital and growth of Nigerian manufacturing industry. This finding implies that production planning significantly affects the Corporate Productivity Performance of firms. Based on these, the study recommends that the Nigerian manufacturing industry should review their production planning concepts and implementation, in order to restore the industry as the base of all development, Embrace a computerised system of production and employ professionals with high technical completive while effective training programmes should be organized for the organizational members who are to be affected by the technological advancement.

Powers (1987) noted that break-even (B/E) analysis could be applied in production planning and control of manufacturing firms even where it is a multi-product firm. This is in line with the studies of Ndaliman and Balaand the assertions of (Levin and Chahine, 2010). It was found that the application of B/E analysis in production planning and control enhances profitability of the firm; this again is in accordance with (Powers, 1987). The third finding is that a relationship exists between the applications of B/E analysis in production planning and control and the frequency with which due dates/schedules are met by the firm. This agrees with (Ilesanmi, no date), who observed that the convenient way of planning production and technical feasibility is to draw activity chart and that activity charts forestall problems connected with due dates. The fourth finding is that a relationship exists between the application of B/E analysis in production planning and control and the production of scraps.

However, this is not in agreement with Ndalima and Bala, who found no link between scraps and application of B/E analysis in production planning and control. It should however be noted that their study was on Block Industries and that the present study indicated that block industries undertake B/E analysis unconsciously. In fact, in the study none of the block industries had a conscious approach to B/E analysis. Many of the business owners were however found to be semiliterate entrepreneurs with one clerk and block moulders. Many of the block moulders were found to be casual workers. Scrap was found to result from lack of or poor planning in production and scheduling. Their results and findings suggest that multi- product firms can apply breakeven analysis to great advantage. The single product firms can easily apply breakeven analysis in production planning and control. Manufacturing firms in Enugu Urban that apply break-even analysis in production planning and control were more likely to be profitable. Also, such firms were more likely to meet due dates/schedules. Manufacturing firms that apply breakeven analysis in production planning and control were less likely to generate scraps. Most block industries do not consciously engage in break-even analysis as a production planning and control tool.

Finch and Cox (1988) opined that process-oriented production planning and control success could be achieved through; the determination of how the five major planning and control functions are accomplished in successful planning and control systems, to determine what environmental factors influenced the designing of successful management information systems to support those functions and to construct a model of the relationships between the influential factors and the designs of the planning and control systems studied. In conclusion, the various factors cannot be generalised, but their relationships can be defined.

Chee (1990) stated that in the development of CPPCS using Oracle software package, an integrated system was developed through three types of diagrams namely, entity-relationship, decomposition, and data flow diagrams provided sufficient information to build the relational database and the forms. It was noted that the Oracle software package was found to be adequate as a platform to build the system. However, it was felt that the software tools were too sophisticated for the requirements of the work and having the most suitable software tools will not guarantee a successful information system. Developers need to have the right approach and techniques. This was the main concern of this project. In conclusion it can be said that by using the system and structured design approaches, an integrated system was developed to meet the information needs of the business studied.

Kanoglu (1996) used a computer-aided model to integrate and evaluate the data to create the reports for production planning in pre-fabrication and it is developed by converting the conceptual system. The weakness in the research was that the computer program and software developed cannot be used for real problems; this is because it is difficult to explain the structure and working of the model. Hence, it is inevitable to convert the conceptual model into applicable and easy understandable software. Karltun *et al.*, (1999) opined that the business process modelling gives a detailed and structured understanding of the relations between the business processes and the problems in the enterprise. In the case of planning and scheduling the production, the business process modelling communicates a simplification and conceptualisation of the enterprises' processes to their personnel. The modelling of the processes provides the enterprises with more complete but simple and understandable images of the business, where the business process perspective accentuates a tight integration between production and sales. Looking upon production planning from a business process perspective means that a contextual perspective is put upon production planning. The effects of this can mainly be seen in two main levels of the enterprises' planning. At the strategic level, the impact of context on the business processes and the related production planning can be clarified.

The modelling reveals the relations between different business processes and the needs for a strategic planning for each identified important variant business process. In the case of a diverging material flow, the needs for a combination of strategic business processes with entirely different focus are apparent. The possibility to model and assure new, expanded or emerging, business processes is another obvious advantage at the strategic level. At the operative level, business process modelling can be used as a tool for developing the demands on the planning activities of an SME. The understanding of the necessary planning activities in the enterprise can be deepened, broadened and spread within the organisation. Business process modelling deals with the relations between details and whole systems. Thus, the relations between the strategic planning, the daily planning and scheduling of the production and the personal planning of the single employee become clearer and more understandable. This means that a change project that includes process modelling will reveal contradictions at any level or between levels.

Karacapilidis and Pappis (1996) observed in his work done on designing a Decision Support System (DSS) for the production management in the textile industry, that the model-based management system gives a comprehensive analysis and synthesis of the MPS procedure in such an environment. This procedure has been developed by considering the specific features of the industry as well as some methods and heuristics that management had to adopt. An example has been presented, which covers most of the scheduling parameters. The system is certainly applicable and especially to those characterised by multi-phase production environments, such as the chemical industry. Implementation issues such as the interrelations of its modules, the existence of multiple machines per phase, various planning horizons and production requirements, can be adapted to any characteristic and/or scheduling policy of such a company. There are two basic reasons that advocate it. First, the coordination of the system's modules through the aid of the database; Oracle plays a central role here, supporting a proper modular design and implementation environment. Secondly, the object-oriented approach during the implementation of the system; the set of objects identified and used for the specific case study can be easily modified in order to cover the needs of a similar firm.

Mugwindiri *et al.*, (2013) noted that in three-dimensional models of real-life system built using FlexSim, which allows the study and analysis of system in a short period of time and come up with required improvement. It was observed from the calculations made in the work that it can be noted that working on production planning without a computerised system that helps in planning production and job scheduling the effective use of the machine or equipment is 43%, which is within the lowest benchmark and requires 17% for it to reach the typical Overall Equipment Effectiveness (OEE) for discrete manufacturers. On the other hand, at 50% for the simulation, it indicates that there is still room for improvement when actual planning is done, although it hasn't reached 60% due to the use of estimated values. With a proper planning of production, it would ensure a higher OEE and improves the production and quality of the throughput.

2. Material and methods

For the purpose of this work, Structured System Analysis and Design Method (SSADM) methodologies will be adopted. It is a form of Systems Development Life Cycle (SDLC) with a procedural approach. Structured System Analysis and Design Method is a set of standards developed for system analysis and application design. SSADM uses a combination of text and diagrams throughout the whole life cycle of a system design, from the initial design idea to the actual physical design of the application. It uses a combination of three techniques namely: Logical Data Modelling: The process of identifying modelling and documenting the data requirements of the system design. The data is separated into entities and relationships. Data Flow Modelling: The process of identifying modelling and documenting how data moves around an information system. Data flow modelling examines processes, external entities and data flow. Entity Behaviour modelling: The process of identifying modelling and documenting the events that affect each entity and sequence in which these events occur.

2.1 System Requirement Analysis

The proposed computerised production planning and control system should be able to perform the following functions: Sign up a system Admin, register other system users by the system Admin, retrieve registered passwords and also remember any registered e-mail and password, notify the user when a wrong e-mail or password is inputted, indicate when a message is sent, achieve effective real-time feedback mechanism, automatically forecast future productions and plot its graph, automatically plan the material quantities needed to carry a production run, automatically schedule production runs from the forecasted future productions, enhanceuser-friendly interfaces, administrative security access, print capability and also store up information in the database.

2.2 Conceptual Model Design

This is the heart of the database design and it is done through developing the entity-relationship (E-R) diagrams for the entities used in the system. The entities are the main objects of the system.

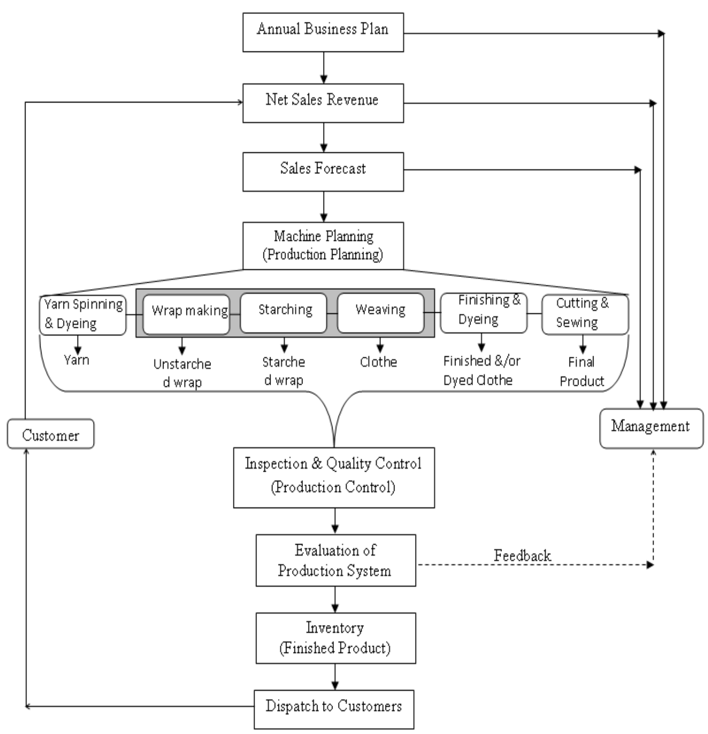


Fig. 1: Conceptual Model Design Diagram

2.3 Unified Modelling Language (UML) Use Case Diagram

Use case diagrams are one of the dynamic behaviour views in UML used to define sets of actions that a system should perform in collaboration with one or more external users of the system (actors). UML use case diagram is used to identify the usage requirements, the sets of actions and the performance of the external users of the modeled system(Mgbemena *et al.*, 2018). A use case diagram must provide a valuable and an observable result to the actors of the modeled system.

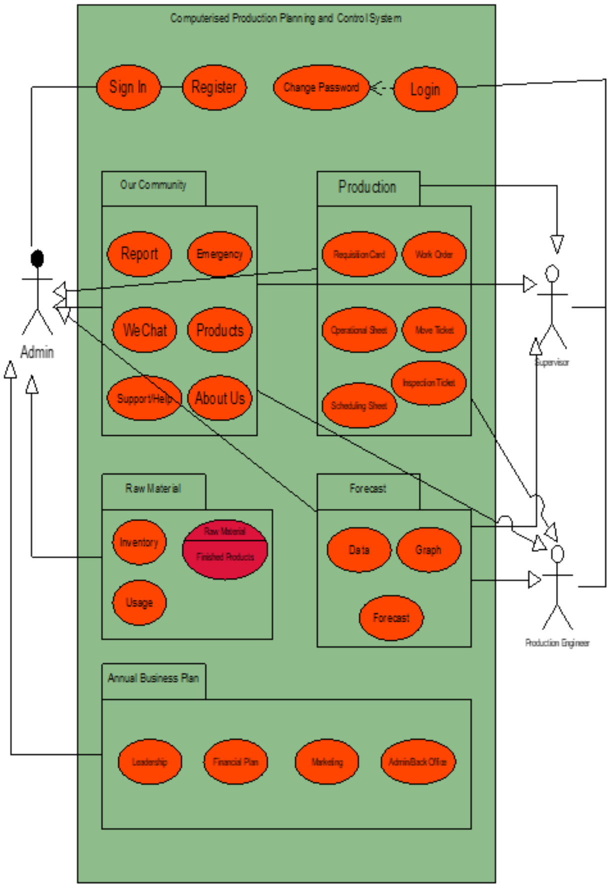


Fig. 2: UML Use Case Diagram of the Analysis of the System Users

2.4 Entity-relationship (E-R) Design

An entity-relationship model is usually the result of systematic analysis to define and describe what is important to process in an area of a business. It is usually drawn in form of boxes (entities) that are connected by lines (relationships) which express the associations' dependencies between entities. The E-R model creates entity set, relationship set, general attributes and constraints. E-R model is based on:

- Entities and their attributes
- Relationships among entities

Entity: An entity can be defined as a thing capable of an independent existence that can be uniquely identified. An entity has properties called attributes.

Relationship: The logical association among entities is called relationship.

2.5 Entity-Relationship Diagrams

The entity of the system includes products entity, sales entity, sales history entity, raw materials entity, production entity, production control entity, raw material usage entity, user's entity etc.

2.6 Entity-Relationship Diagrams for Production Planning and Control System

Figure 3 depicts the required information needed to get a user of the system registered; figure 4 depicts the necessary information a registered user of the system is required to provide to be able to login into the system, figure 5 explains the drop-down main menu of the system.

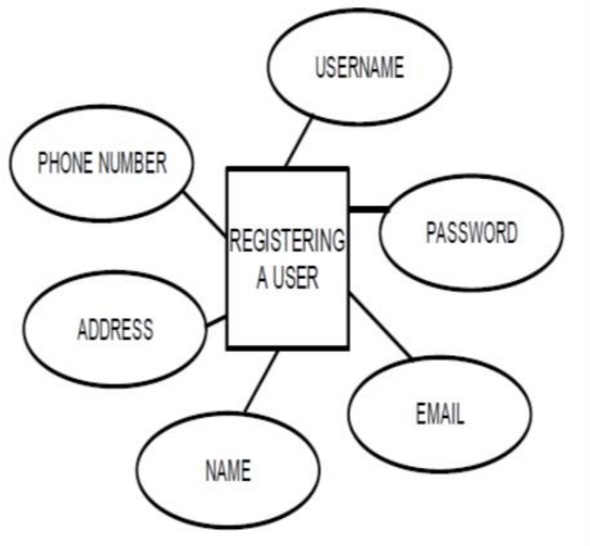


Fig. 3: Registering a User Entity-Relationship Diagram

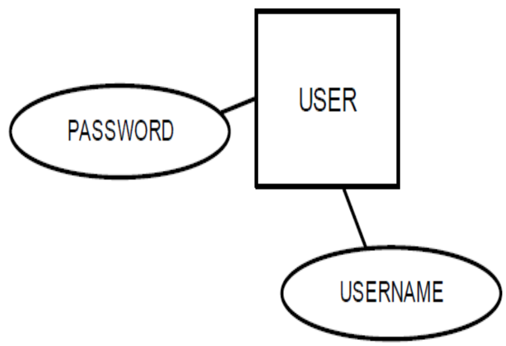


Fig. 4: User Entity-Relationship Diagram

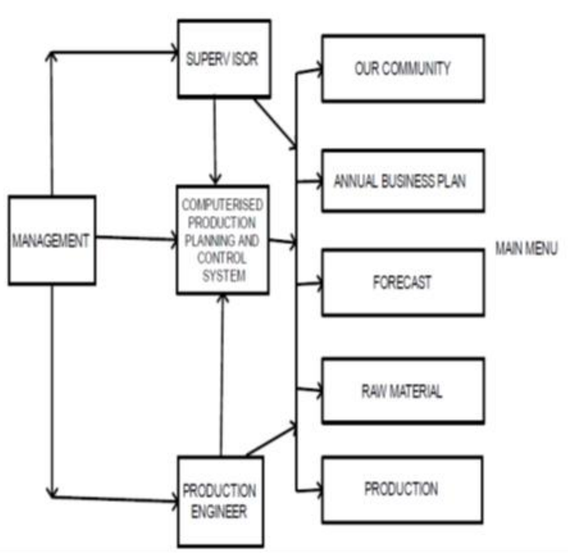


Fig. 5: Main Menu Entity-Relationship Diagram

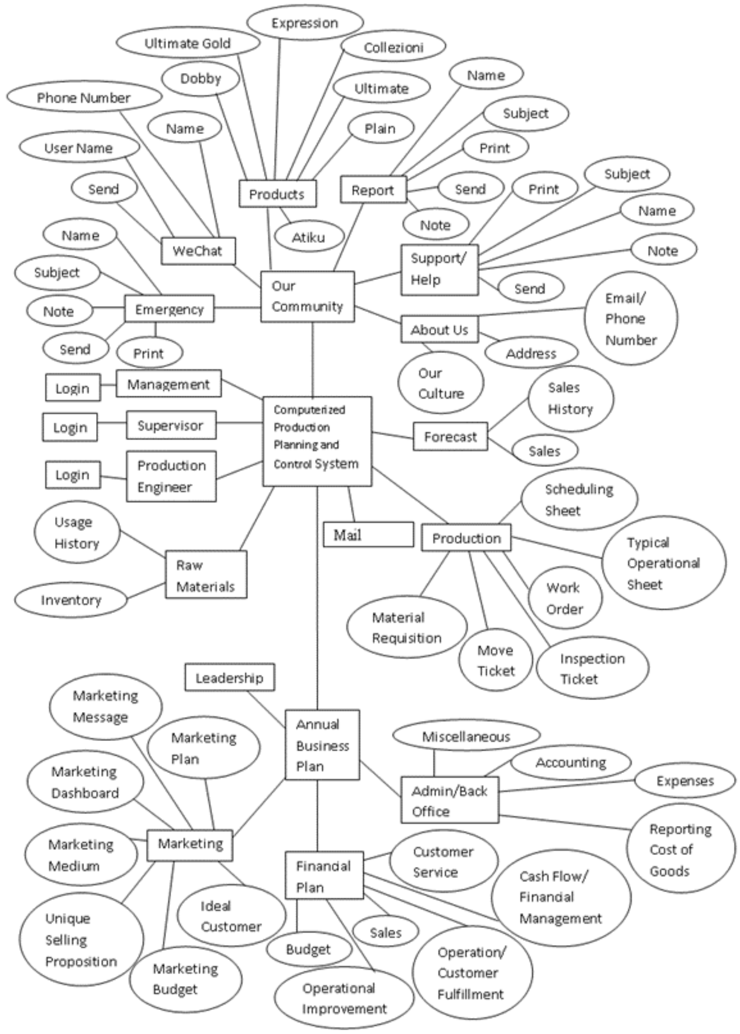


Fig.6: Computerised Production Planning ControlSystem Entity-Relationship Diagram.
Figure 6 contains all the entities and their interactions in the system

2.7 Physical Structure Design

The physical structure design gives an overview of the flow diagrams of the software with regards to the modules and their functions.

Sign-Up Module: The user of the production planning and control system registers his/her name and it is saved to the table in the database.

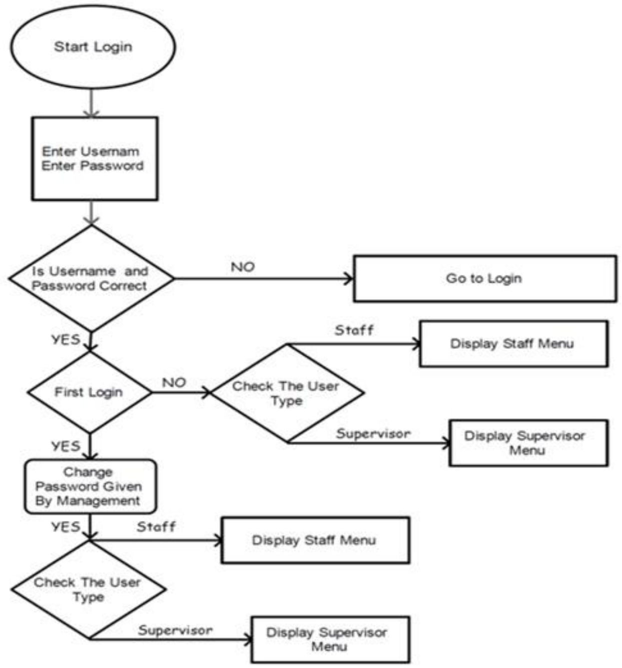


Fig. 7: Login Module Diagram

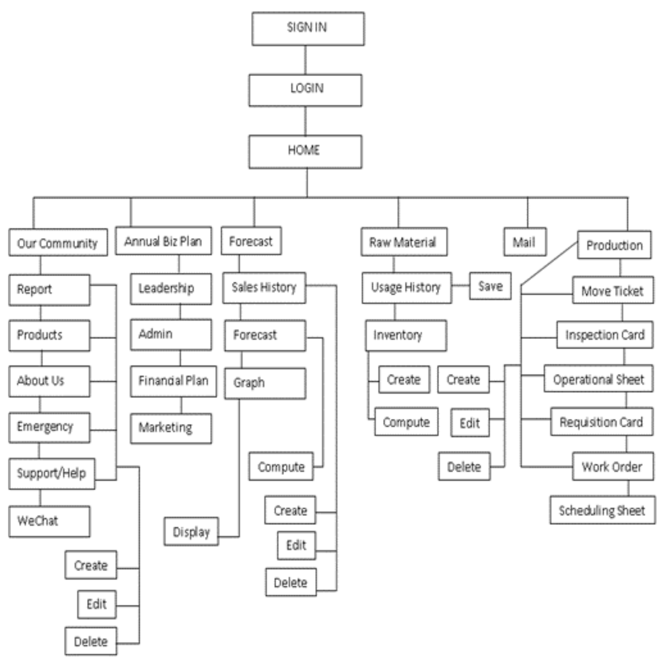


Fig. 8: Site Map of the Computerised Production Planning and Control System

Figure 7 describes the system's login flow chart while figure 8 is the system's site map which shows the features of system.

2.8 Tables of Data

Table 1: Historical Data of Production

		Production Output (m)				
S/N	**Month**	**2013**	**2014**	**2015**	**2016**	**2017**
1	Jan.	87356.88	94550.61	173779.63	281479.63	198346.00
2	Feb.	138289.44	222639.63	158005.86	235093.62	283340.35
3	Mar.	116453.88	101700.42	358136.49	128333.46	270780.98
4	Apr.	49395.36	242685.45	303042.58	119813.86	236491.86
5	May	43511.91	269562.66	413700.78	176977.25	318139.75
6	Jun.	160580.67	362846.91	134572.76	171045.28	415160.84
7	Jul.	132054.63	319730.28	237088.41	231664.13	372933.91
8	Aug.	225827.49	243049.62	277151.67	289663.37	297758.37
9	Sept.	312501.78	97776.90	369703.22	378957.78	154739.19
10	Oct.	246138.66	147249.12	159636.39	319613.31	204428.00
11	Nov	218057.31	167219.92	297596.43	272792.52	224860.60
12	Dec	139685.73	212924.16	281479.62	166032.35	271032.68
TOTAL		1,869,853.74	2,481,935.68	3,163,893.84	4,022,349.66	3,248,012.53

3. Results and Discussions

3.1 System Development

The computerised production planning and control system was developed using a programming language known as PHP. PHP is a server-side language (which means that it runs only on a server) that is used in developing online and offline systems. The system makes use of a MySQL database for storing user data, inventory report, forecast history, processed data (information), etc. The database stores other details of production processes such as material acquisition ticket, work sheet order, move ticket etc. The system is structured in layers; the first user to sign up into the system becomes the manager of the system and has access to all layers. The manager of the system can create new roles such as supervisor role and Engineer role. Each role is assigned a unique password that the user is expected to change it on the first login.

Index Interface: This interface comes up once the system is launched. It is the home page of the system and contains the menu of the system. From the index page, the users of the system can either register or login as seen in the menu bar at the right top corner of the page. The first user to be registered in the system automatically becomes the manager of the system and the only authorised (the only user able to access registration page) user to get other users registered either as a supervisor or a worker. As depicted in figure 9, the sign-up interface comes up once register button is clicked from the index page. For a new user to access the system, registration of the user will be made in this page and the followings are the requirements needed to get the user registered, Name, E-Mail Address, Home Address, Phone Number and Password.

As shown in figure 10, the login interface grants access to an already registered user. The user either login as a supervisor or a worker. The requirements to login are the e-mail address and password. When the user is logging in for the first time, the system will automatically require the user to change the password used in the registration before granting the login access. The system can retrieve a forgotten password and to remember the e-mail address and the password of every user that has been registered in the system.

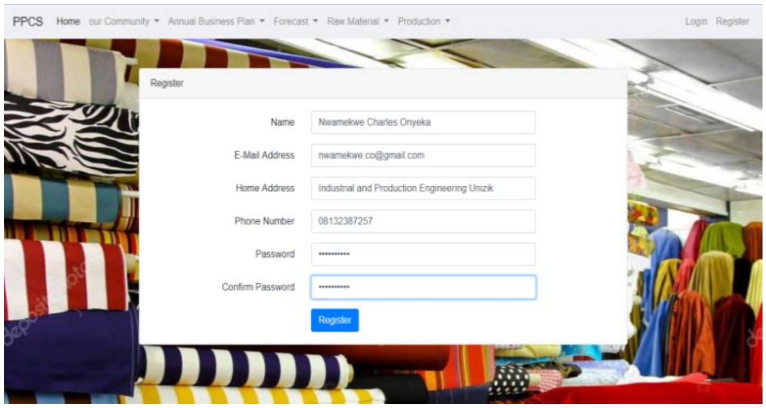


Fig. 9: Sign up Interface

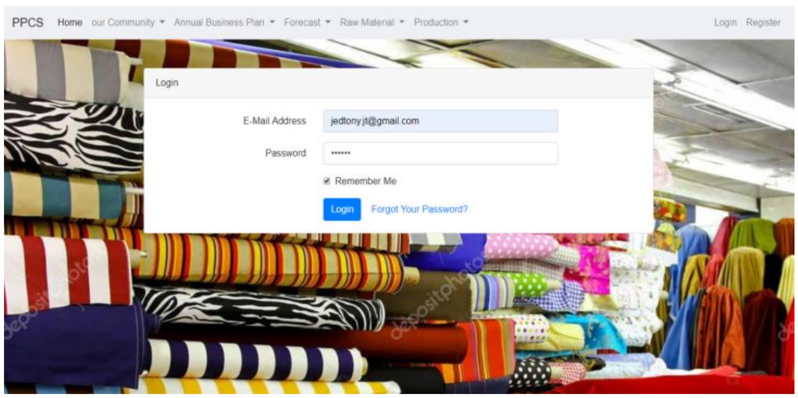


Fig. 10: Login Interface

The Report Interface is used to send the report as required in the company. It contains the subject of the report, name of the sender, the report, the submission and the print buttons.
The Support/Help Interface is used to request for a support or help by the users of the system.
The Emergency Interface is used when the user of the system needs to make an emergency report or support request.
The Material Requisition Card Interface is used to request for materials by the users of the system.
The Move Ticket Interface is used to move raw materials, tools, finished product etc to different places like production plant, warehouse etc.
The Inspection Ticket Interface is the interface where the records of the inspections carried out both on the finished product and inventory are recorded and submitted as well as saved in the database of the system.
The Work Order Sheet Interface displays a sheet which is used to place order of work. Considering the nature of the production involved which produce to stock and produce on customer's order. The work order specifies the quantity to be produced, design descriptions, delivery date etc.
The Typical Operational Sheet Interface display the descriptions of every operations involved in the production processes and the machines used in carrying out each of the operations. It aids the engineers/workers when clarifications are needed in terms of operational processes. It also serves as a guide in the production of the products.

3.2 System Implementation

3.2.1. Implementation of the Developed System's Interfaces

Raw Data Interface
This interface as depicted in figure 11, displays the raw data as was inputted into the system. The raw data is the monthly production data collected from the textile company. This interface automatically runs the raw data to produce the required future production data following the time series model principles.
Forecast Interface: This interface as shown in figure 12, displays the forecasted figures automatically generated by the system gotten from the input data. It contains the lower and upper confidence bound. The confidence bound is

important because of the type of production being carried in the company (produce to stock) and also considering their inventory capacity (finished product storage capacity).

Graph Interface: This interface, displays the graphical interpretation of the forecasted figures. It plots the forecasted figures with their confidence bound into a graphic representation.

Raw Material Interface

At this interface, which is shown in figure 13, the quantity of materials needed for production runs are computed. The waste factor was considered, and the value is estimated at 0.01 per-unit-meters.

Feedback system: The computerised system has a better and faster feedback mechanism compared to manually operated system. The system can send messages, receive messages with a beep sound and detect errors when necessary.

Error Interface: This display comes up when inputs in the system is wrong such as on the login interface where when the login details are not correct, it displays error. The same thing happens when inputs characters that are not numbers on the raw material and scheduling interfaces.

Data Storage Ability:The computerised system has a MySQL database which stores all the information in the system. Compared to manual documented information, it is safer, faster and less stress to save data with the computerised system.

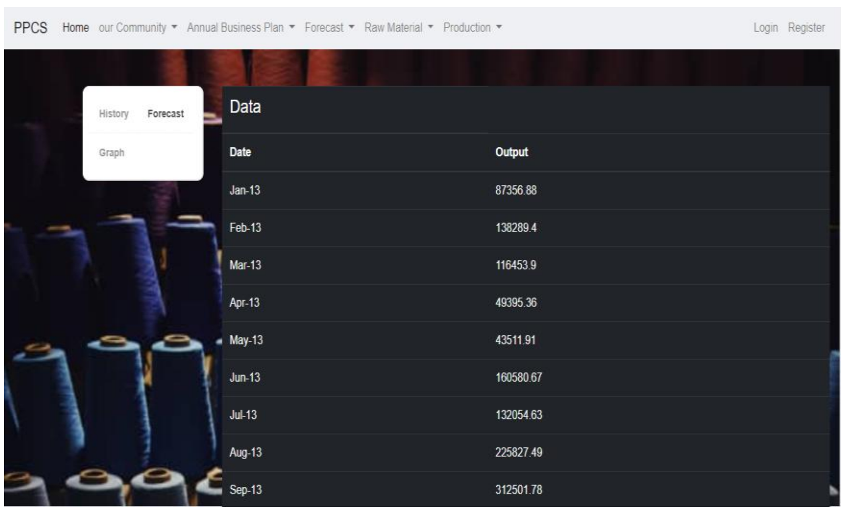


Fig. 11: Raw Data Interface

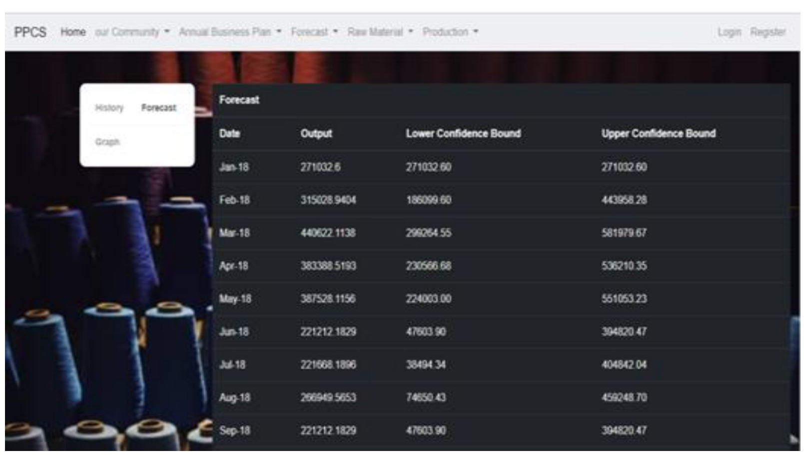
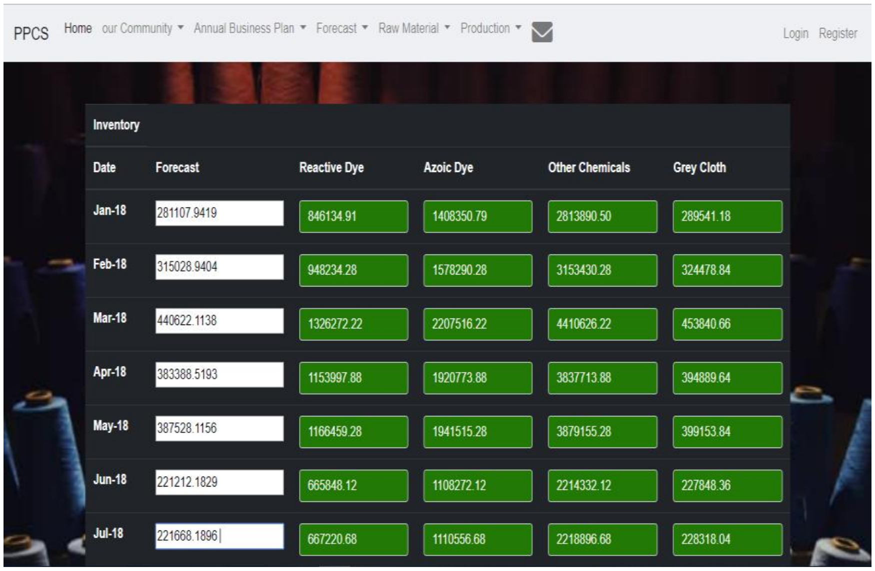


Fig. 12: Forecast Interface



Date	Forecast	Reactive Dye	Azoic Dye	Other Chemicals	Grey Cloth
Jan-18	281107.9419	846134.91	1408350.79	2813890.50	289541.18
Feb-18	315028.9404	948234.28	1578290.28	3153430.28	324478.84
Mar-18	440622.1138	1326272.22	2207516.22	4410626.22	453840.66
Apr-18	383388.5193	1153997.88	1920773.88	3837713.88	394889.64
May-18	387528.1156	1166459.28	1941515.28	3879155.28	399153.84
Jun-18	221212.1829	665848.12	1108272.12	2214332.12	227848.36
Jul-18	221668.1896	667220.68	1110556.68	2218896.68	228318.04

Fig. 13: Computerised computation of Quantity of Materials Needed for the Production.

Scheduling of the Product-Mix for the Product Brands; as stated earlier, the company has six (6) product brands which utilise the same resources and technology. The scheduling of these products should be in a way that will give an optimum and efficient use of the production resources and the technology.

A Production Possibility Frontier (PPF) will be used to analyse the scheduling result of the system. PPF is a correlation curve which illustrates various combinations of the amounts of two products which can be produced with the same inputs say, resources and technology, where the given inputs are fully and efficiently utilised per unit time. The points on the curve in figures 14, 15, and 16 show the efficient utilisation of the inputs for improved throughput. The points under the curve show that the inputs were underutilised while the points above the curve show that the inputs were over utilised thus, the efficient utilisation of the inputs. The products are, Atiku, Expression, Collezione, Ultimate, Dobby and Plain. The products will be grouped in pairs such that the pairs will have the most similar processes, inputs and otherwise.

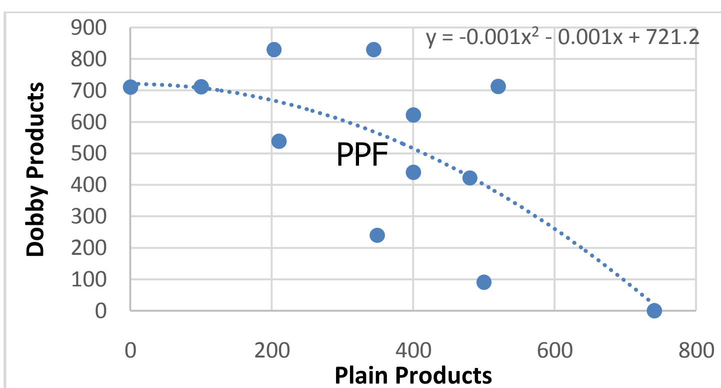


Fig. 14: A PPF Graph of Dobby-Plain Product mix

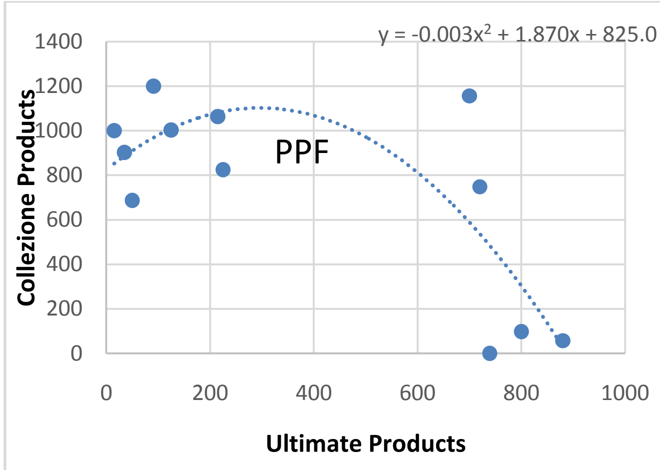


Fig. 15: A PPF Graph of Collezione-Ultimate Product mix

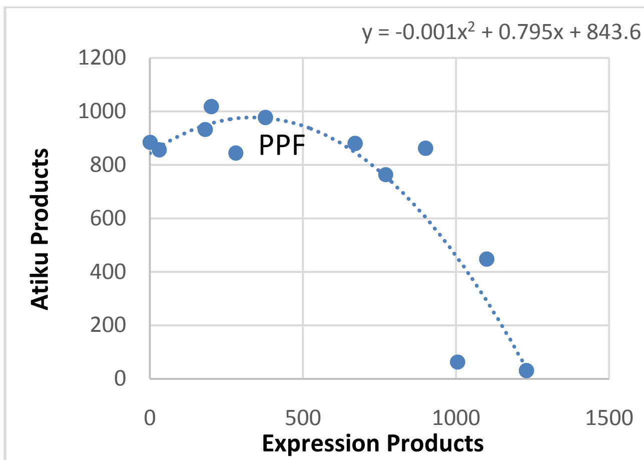


Fig. 16: A PPF Graph of Atiku-Expression Product mix

From figure 14, it can be observed that the system was able to produce four (4) efficient product-mix for the production runs. It can also be observed that the system produced the same number of efficiencies in fig. 15. In fig. 16, there was a significant improvement in the efficiency of the system. This was shown in the PPF, as five (5) of the points were on the curve and the inefficiencies of the system were not so wide compared to the first two (2). The models generated from the PPF are listed in equations 1, 2, and 3.

$$y = -0.001x^2 - 0.001x + 721.2 \quad (2)$$
$$y = -0.003x^2 + 1.870x + 825.0 \quad (3)$$
$$y = -0.001x^2 + 0.795x + 843.6 \quad (4)$$

A negative correlation of the product mix can be observed, which explains the fact that as one product increases in the production runs the other decreases. With these correlation models, an optimum and efficient throughput can be obtained. The equations can be integrated into the system to schedule an effective and efficient future production runs with the product mix.

3.2.2. Effective Feedback for the System

When the raw material inventory gets to a certain level, the system will notify the storekeeper with both voice alert and visual display, who in turn notifies the managers with messages through the system. This feedback system helps to provide information on the inventory level of the company. It ensures a constant supply of the raw materials needed to run the productions. The distance between the production plant and the managerial office makes it difficult for order to arrive early enough. This is a bottleneck to the production delivery dates but with the application of the computerised system it is possible to send and receive messages in few seconds. Changes can easily be made to the orders and this in turn improves the delivery dates. The application of the computerised system makes it possible to plan the material needed for every production run efficiently and effectively within seconds as shown in figure 17. The system was also tested using three (3) different system users from the plant which was compared with the manual computation. Three (3) different readings for the time taken to compute the material needed for the production runs were taken and a graph of its processing time was plotted as shown in figure 18.

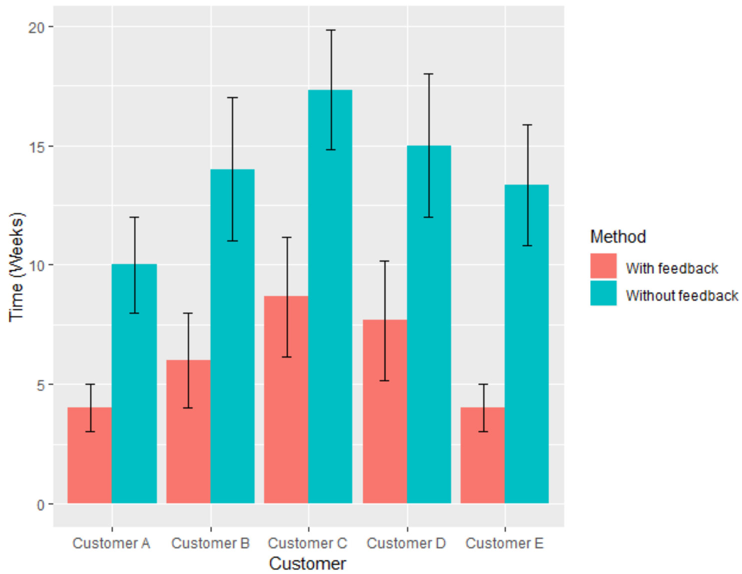


Fig. 17: Customers' delivery dates with the system with effective feedback system including their error bars.

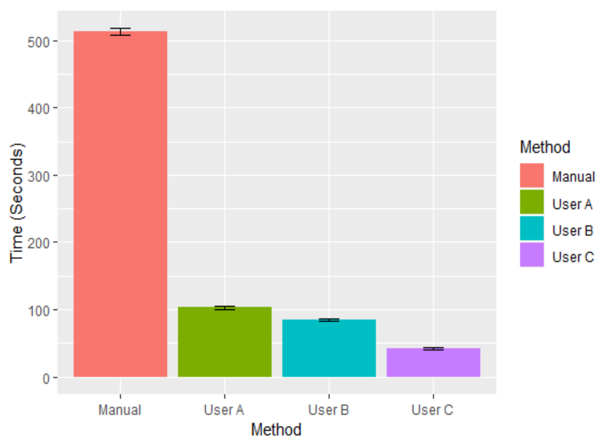


Fig. 18: Average system processing time with error bars compared with manual computations

3.2.3 Productivity of the Computerised System

Productivity is defined as the efficient use of all factors of production in the production process. It is a measure of efficiency of production. Productivity measure is expressed as the ratio of output to inputs used in a production process.

$$\text{Productivity} = \frac{output}{input} \text{ (meters)} \quad (4)$$

$$= \frac{total\ output}{total\ input}$$

Total input =

$$\frac{1{,}869{,}853.74 + 2{,}481{,}935.68 + 3{,}163{,}893.84 + 4{,}022{,}349.66 + 3{,}248{,}012.53}{5}$$

= 2957209

Total output = 281107.94 + 315028.94 + 440622.11 + 383388.52 + 387528.12 + 221212.18 + 221668.19 + 266949.57 + 278113.39 + 304681.37 + 338602.37 + 464195.54 = 3903098

$$\text{Productivity} = \frac{total\ output}{total\ input}$$

=1.32 meters-per-unit production (Productivity increment)

3.2.4. Efficiency of the Computerised System

Fig. 19: A Graph of Total Production Output against Year

Efficiency is concerned with producing goods and services with the optimal combination of inputs to produce maximum output for the minimum cost. Efficiency is a measure expressed as the ratio of standard output to actual output. It can be expressed as a percentage by multiplying with 100.

$$\text{Efficiency} = \frac{standard\ output}{actual\ output}\ \% \quad (5)$$

NB: standard output = 3,114,857.17m

$$\text{Efficiency of the system} = \frac{3{,}114{,}857.17}{3903098} \times 100$$

= 79.8%

3.2.5 Generated Tables of Data

Table: 2: Forecast of the Future Productions as Generated by the System

Date	Output	Lower Confidence Bound	Upper Confidence Bound
Jan-18	281107.9419	165882.36	165882.36
Feb-18	315028.9404	186099.60	186099.60
Mar-18	440622.1138	299264.55	299264.55
Apr-18	383388.5193	230566.68	230566.68
May-18	387528.1156	224003.00	224003.00
Jun-18	221212.1829	47603.90	47603.90
Jul-18	221668.1896	38494.34	38494.34
Aug-18	266949.5653	74650.43	74650.43
Sep-18	278113.3874	77069.21	77069.21
Oct-18	304681.3676	95192.35	95192.35
Nov-18	338602.3661	120995.99	120995.99
Dec-18	464195.5395	238733.79	238733.79
Jan-19	406961.945	173880.24	173880.24
Feb-19	411101.5413	170612.89	170612.89
Mar-19	244785.6086	-2916.16	-2916.16

Apr-19	245241.6153	-9495.96	-9495.96
May-19	290522.991	28912.57	28912.57
Jun-19	301686.8131	33353.94	33353.94

Table 3: Weekly Production Scheduling from the Computerised System

Month	Forecast (unit-per-greycloth)	Week 1	Week 2	Week 3	Week 4
Jan-18	2811	1124	937	-	749
Feb-18	3150	1260	-	1050	840
Mar-18	4406	-	1468	1762	1174
Apr-18	3834	1533	1278	1022	-
May-18	3875	1550	1291	-	1033
Jun-18	2212	884	737	-	589
Jul-18	2217	886	739	-	591
Aug-18	2669	1067	889	711	-
Sep-18	2781	1112	902	-	741
Oct-18	3047	1218	1015	-	812
Nov-18	3386	1354	1128	-	902
Dec-18	4642	-	1547	1856	1237

***greycloth = 100meters**

Table 4: Product Mix Production Scheduling from the Computerised System

Month	Atiku	Expression	Collezione	Ultimate	Dobby	Plain
Jan-18	770	763	880	57	344	830
Feb-18	377	977	35	902	400	622
Mar-18	280	844	15	1000	203	830
Apr-18	1230	30	225	825	100	712
May-18	1005	62	800	98	400	440
Jun-18	200	1018	215	1063	520	713
Jul-18	180	932	125	1003	480	422
Aug-18	670	880	91	1200	210	539
Sep-18	900	862	739	0	0	711
Oct-18	0	884	50	687	741	0
Nov-18	30	856	700	1156	349	240
Dec-18	1100	447	720	748	500	91

Table 5: Computed Values of the Quantities of Material Needed for the Production Runs

Date	Forecast (Meters)	Reactive Dye (3 grams/meter + waste factor)	Azoic Dye (5 liters/meters + waste factor)	Other Chemicals (10 liters/meters + waste factor)	Grey Cloth (1.02 meters + waste factor)
Jan-18	281107.9419	846134.91	1408350.79	2813890.50	289541.18
Feb-18	315028.9404	948237.11	1578294.99	3153439.69	324479.81
Mar-18	440622.1138	1326272.56	2207516.79	4410627.36	453840.78
Apr-18	383388.5193	1153999.44	1920776.48	3837719.08	394890.17
May-18	387528.1156	1166459.63	1941515.86	3879156.44	399153.96
Jun-18	221212.1829	665848.67	1108273.04	2214333.95	227848.55
Jul-18	221668.1896	667221.25	1110557.63	2218898.58	228318.24

Aug-18	266949.5653	803518.19	1337417.32	2672165.15	274958.05
Sep-18	278113.3874	837121.30	1393348.07	2783915.01	286456.79
Oct-18	304681.3676	917090.92	1526453.65	3049860.49	313821.81
Nov-18	338602.3661	1019193.12	1696397.85	3389409.68	348760.44
Dec-18	464195.5395	1397228.57	2325619.65	4646597.35	478121.41

***waste factor = 0.01**

3.3Discussion

This thesis describes the development and implementation of a computerized production planning and control system. It integrates the forecasting, material planning and scheduling of products to provide a real-time feedback and product-mix scheduling of the company. The first step in the development of the system was to adopt the methodology which is SSADM. The design of the system was initiated by first determining the system requirements which are the functions the system is meant to do. The conceptual design was made. This design was to help understand the entire system requirements. Entity-Relationship diagrams were used to design each entity using pencil wireframe software. After that, all the entities were integrated together to design the entire system. The UML use case diagram was used to analyse the relationships between the actors of the system and the system. It combines different shapes and lines to illustrate the inputs of each actor of the system and the expected output results. It also explains the accessibility limit of each actors of the system has over the system. The structural diagram of the system was developed using module diagrams. The login, register, etc. module diagrams were each developed which was integrated to illustrate the system structural flow diagram.

The system was developed using PHP programming language. Each interfaces of the system were developed with an effective feedback. The index interface is the home page of the system and was designed to contain the menu bar of the system, name of the system and what the system is meant to do. The sign up and login interfaces were developed for the registration and login of the system users. The first user to register on the system after installation automatically becomes the manager of the system and the only user with the registration access. Work order sheets were developed to receive orders from the customers. This was considered since the company both produces to stock and on customers' orders. The material requirement and scheduling sheet interfaces were developed for the planning of the materials needed for every production run and to schedule the quantity in each production run including that of the product mix respectively. The typical operational sheet was developed to help the plant workers with different operations involved, the machines and the processes. Currently, the company's operational sheet is on a notice board.

After the production of products, the inspection ticked developed will be used as the record book for the inspection of the products. While the move ticket will be used to record the quantity of the products moved to the inventory from the production plant. When the raw material inventory becomes low, the material requisition card will be used to alert the management for the materials needed for the production runs. It is also used by the plant engineers to request for materials needed for production run. Different response systems were developed in the system such as report response system, support/help response system and emergency response system to make communications effective, fast and easy. The system was also designed to detect error when inputting information in the system and to remember the user's sign up details. Some of the interfaces were not developed considering the scope of the work and time.

The system was implemented using data gotten from the textile company. A five-year production output was gotten and inputted in the forecast interface of the system. The next year production forecast was obtained in meters using a time series forecast model; $ED_{t+1} = f(ED_t, ED_{t-1}, ED_{t-2}, ED_{t-3}, \ldots, error)$, where t is the present month, $t + 1$ is the next month, $t - 1$ is the previous month, $t - 2$ is two months earlier, etc, were used in the production planning. The graph of the forecast was generated with its upper and lower confidence bounds as shown in fig. 12. These upper and lower limits are the possible production limits, meaning that the forecast can go up or below the actual prediction. Assuming the standard length for grey cloth to be 100meters (100meters-per-greycloth), the forecast was divided by 100. The production scheduling was done in greyclothes-per-production. This means that it was done using the number of grey clothes to be produced as shown in table 3. The product mix scheduling was subsequently generated by the system. This plans the quantity of each product brands; Atiku, Ultimate, Expression, Collezione, Dobby and Plain to be produced to obtain an optimal and efficient use of inputs. The materials needed for the productions were planned to use the system. The quantity of each materials use in the production was evaluated using quantities of each materials per-unit-meter. The total quantities of materials needed were computed by the system taking the waste factor to be 0.01. Waste factor is the estimated amount of each material to be wasted during the production run. The effective real-time feedback was tested. This helps to alert the storekeeper when the production materials have reduced to a certain level. The response systems of the system were used to send and receive messages and it was fast, easy and swift to operate.

The work was validated on the company's production plant and R-statistical software was used in the analysis of the results. The 2018 total production was compared if the system was implemented and used during same period. It was observed that some significant increase would have been made if the system was used. With the introduction of the effective feedback system, five customers' orders were randomly selected from the previous orders and the delivery dates of the orders were recorded. These were compared to the delivery dates obtained when the system was implemented. The quantities ordered with the delivery dates were compared, the pink bars are the computerised system while the blue bars are manual system with an error bar on each of the bars. The same order quantities were used in the analysis. The delivery dates were almost reduced to half with the implementation of the computerised system. The error bars were showing that there was no significant difference in each of the system but when compared together it showed a significant difference in the delivery dates. Then the processing time of the system was computed compared to manual processing time. Three different categories of system users were used. The bar represents the manual processing time, the green bar represents user A (a less computer literate user), blue bar represents user B (a computer literate user) and purple bar represents user C (a professional computer user).

The computerised system was discovered to have saved more time no matter the category of the system user when compared with the manual system. From figure 18, it can be said that the faster the system user, the more time to be saved. To test the reliability of the product mix scheduled, Production Possibility Frontier (PPF) was used in the analysis using R-statistical software. PPF could be a curve or straight line depending on the correlation of the input variables. It is used to evaluate the efficiency of the system. The points on the curve represent the optimal and efficient combination of the products to give maximum throughput. PPF curves of the product-mix scheduling were established with high efficiency. This means that at the points on the curve, the company will make the most efficient use of the inputs to produce the optimal quantities of the products. Careful look on the curve will show that the product mix schedules were all very close to the curve, showing the level of efficiency in the system. Models were generated and could be integrated into the system for the best product-mix schedules to improve productivity and efficient utilisation of resources and technology. The models are as shown; $y = -0.001x^2 - 0.001x + 721.2$ (y = Dobby, x = Plain), $y = -0.003x^2 + 1.870x + 825.0$ (y = Collezione, x = Ultimate), $y = -0.001x^2 + 0.795x + 843.6$ (y = Atiku, x = Expression), where x is a function of y.

The efficiency of the system and productivity was measured to be 79.8% and 1.32meters-per-unit production (productivity increment) respectively. The analysis of these experimental results show that the implementation of this newly developed CPPCS was able to reduce the delivery dates of customers' orders through the introduction of a real-time effective feedback system and effectively scheduled the product mix of the company for an efficient use of resources and an improved throughput.

4. Conclusion

It can be observed that computer applications are very important in every field of human endeavor. This thesis work described developing a computerised production planning and control system for manufacturing sector using a textile company as a case study. With this new system, the difficulties encountered with manual processes of carrying out, production planning and control, documentation of production data, sending and receiving of information, forecasting, material planning and scheduling of productions are eliminated. It was observed that the computerised system was able to save an enormous amount of the time needed to compute the material required for the production runs, improved productivity, gives accurate results as compared with manual computations, gives a safe, fast and automated feedback with a beep sound and stores (retrieves) all the information in the system with error detection system when the need arises.

The computerised production planning and control system reduces the workload on the workers in the manual computations, saves time, increases efficiency, and gives accurate results. The production plans for each product were obtained with a very reasonable efficiency. The information on the system will be saved and safe, errors minimized and the reports generated will be accurate thereby increasing productivity. The help and troubleshooting buttons on the navigation bar in the home page serve as the safety devices for information retrieval and system restoration respectively for the system users when there is loss of information or errors in the system. The system was designed and developed to be user friendly, cost effective, fast and flexible as much as possible.

5. Recommendations

Computerised production planning and control system is recommended to the textile company, adopting the computerised production planning and control system will efficiently eliminate the challenges faced with the manual methods of production planning and control, data storage etc.Computerised production planning and control system is highly recommended to manufacturing companies especially for SMEs. This system provides protection and accurate records of data and computations. The adaptation of the system does not require many employees and the user only requires basic computer skills to operate it.

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