



Form Patents No. 4

CERT. No 000452

FEDERAL REPUBLIC OF NIGERIA

Patents and Designs Act.
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Certificate of Registration of Business Method Patent

RP: F/PT/NC/2024/12948
Date of Patent: 23/06/2024
Date of Sealing: 01/07/2024

President of the Federal Republic of Nigeria and Commander-in-chief of the Armed Forces
BOLA AHMED TINUBU, GCFR.

Whereas a request for the grant of a patent has been made by: **CHARLES ONYEKA NWAMEKWE; ENGR. PROF. CHIKA EDITH MGBEMENA; ENGR. DR. NKEMAKONAM CHIDIEBUBE IGBOKWE; ENGR. DR. CHARLES CHIKWENDU OKPALA ALL OF DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING, NNAMDI AZIKIWE UNIVERSITY, AWKA C/O TIC/IPTTO NNAMDI AZIKIWE UNIVERSITY, AWKA, ANAMBRA STATE**

For the sole use and advantage of an invention for: **AN AUTOMATED PRODUCTION PLANNING AND CONTROL DEVICE**

AND WHEREAS the Federal Government being willing to encourage all invention which may be for public good, is pleased to accede to the request:

KNOW YE THEREFORE, that I do by this Instrument give and grant unto the person(s) above named and any successor(s), executor(s), administrator(s) and assign(s) (each and any of whom are hereinafter referred to as the patentee) by special licence, full power, sole privilege and authority, that the patentee or any agent or licensee of the patentee may subject to the conditions and provisions prescribed by any statute or order for the time being in force at all times hereafter during the term of years herein mentioned, make, use, exercise and vend the said invention throughout the Federal Republic of Nigeria, and that the patentee shall have and enjoy the whole profit and advantage from time to time accruing by reason of the said invention during the term of **EIGHT years** from the date first above written on this Instrument: **AND** to the end that the patentee may have and enjoy the sole use and exercise of the full benefit of the said invention, I do by this Instrument strictly command all citizens of the Federal Republic of Nigeria that they do not at any time during the continuance of the said term either directly or indirectly make use of or put in practice the said invention, nor in anywise imitate the same, without the written consent, licence or agreement of the patentee, on pain of incurring such penalties as may be justly inflicted on such offenders, and of being answerable to the patentee according to law for damages thereby occasioned:

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MADE this: 1st DAY OF JULY, 2024

JANE IGWE
Registrar

TITLE OF INVENTION:

An Automated Production Planning and Control Device

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DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING

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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 an Automated Production Planning and Control Device (APPCD). This innovative research presents the activities carried out in the design development and implementation of an APPCD applicable to manufacturing organizations, using a textile company in Nigeria for practicability. The control device system is designed to handle the forecast, material planning product-mix scheduling 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 language and MySQL as the database file. Time series forecasting principle was adopted using a hybrid model of Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and Long Short-Term Memory (LSTM) network. The novelty of this innovative research is that the developed system can provide both visual and audio display of a real-time feedback on the raw material inventory, automated monitoring and forecasting of the production, a real-time production level display 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.

Field of Invention or Technical Field:

The current invention relates broadly to the field of engineering, with a specific focus on an automated device for production planning and control.

Background of the Invention:

The evolution of production planning and control systems can be traced back to the early stages of the industrial revolution, where manual methods were predominant (Sharma, 2024). These manual approaches were labor-intensive, error-prone, and struggled to keep up with the growing complexity of manufacturing systems (Sharma, 2024). As industries expanded during the first Industrial Revolution, mechanization brought about new challenges and opportunities,

necessitating more structured approaches to production control (Sharma, 2024). Basic inventory control methods, scheduling techniques, and workflow management systems emerged as early production control strategies (Sharma, 2024).

In the contemporary context, the development and implementation of automated production planning and control systems can significantly benefit from advanced technologies and automation (Sharma, 2024). Studies have shown that artificial intelligence/machine learning (AI/ML) holds promise in revolutionizing modern manufacturing processes on a large scale (Sharma, 2024). Leveraging AI/ML can enhance efficiency, accuracy, and competitiveness in manufacturing operations (Sharma, 2024).

The evolution of production planning and control systems has been closely intertwined with technological advancements in manufacturing. The second Industrial Revolution marked a pivotal shift towards automation, with the introduction of assembly lines and mass production techniques pioneered by companies like Ford (Guo et al., 2020). This era necessitated more sophisticated production planning and control systems to manage the increased volumes and complexities of production (Guo et al., 2020). Subsequently, the rise of computer technology in the latter half of the 20th century transformed production planning and control through the emergence of Enterprise Resource Planning (ERP) systems, which integrated various business processes, including production planning, into a unified framework (Guo et al., 2020). These systems significantly enhanced efficiency, accuracy, and the capacity to handle larger volumes of data and more intricate production environments (Guo et al., 2020).

The integration of automation and Computer-Integrated Manufacturing (CIM) has enabled the development of advanced manufacturing systems for production and operations management (Guo et al., 2020). The convergence of automation and CIM has paved the way for the implementation of innovative technologies such as Material Requirements Planning (MRP) systems and Advanced Planning and Scheduling (APS) systems (Guo et al., 2020). These systems play a crucial role in optimizing production processes, enhancing resource utilization, and improving overall operational efficiency (Guo et al., 2020).

Moreover, the utilization of AI/ML and cyber-physical systems in manufacturing operations has opened up new possibilities for enhancing production planning and control (Guo et al., 2020). By leveraging AI/ML-driven technologies, manufacturers can achieve higher levels of

automation, precision, and adaptability in their production processes (Guo et al., 2020). The incorporation of smart manufacturing practices, digital technologies, and Internet of Things (IoT) devices is reshaping the landscape of manufacturing towards more sustainable and performance-driven operations (Guo et al., 2020).

In recent years, the manufacturing industry has undergone significant transformations due to the integration of digital technologies within the industry 4.0 paradigm. Technologies such as the IoT, AI/ML, and big data analytics have revolutionized production processes (Oluyisola et al., 2021). Despite these advancements, traditional production planning and control systems face challenges in modern manufacturing environments. These challenges include the complexity of manufacturing processes with multiple variables and dependencies, the need for systems that can quickly adapt to changes in production schedules and supply chain disruptions, the demand for highly efficient production processes to meet competitive pressures, and the management of the vast amounts of data generated in manufacturing settings (Oluyisola et al., 2021).

To tackle these challenges, researchers have proposed innovative solutions. For example, the development of smart production planning and control systems utilizing AI/ML and big data analytics can enhance adaptability and efficiency in production processes (Oluyisola et al., 2021). Incorporating advanced technologies such as IoT devices for real-time monitoring and tracking of inventory levels can improve decision-making and operational performance (Oluyisola et al., 2021). Strategic solutions like digital twin technology, scenario planning, and risk management strategies have been recommended to enhance production planning and control systems (Ocholor, 2024).

Object of the Invention:

The invention unlike the existing system was able to achieve the following:

- An advanced sensor technology (IoT device) was leveraged on to enhance the accuracy and reliability of production data inputs for automated planning and control.
- The provision of real-time feedback and monitoring capabilities, allowing for quick adjustments to production plans based on changing conditions or demand fluctuations.

- The automated system can easily scale with growing production demands and complexities, adapting to new products or changes in production requirements.
- It provides decision-makers with comprehensive data and insights for informed decision-making, optimizing resource allocation and production outcomes.
- The Integration of IoT sensor and data analytics (hybrid algorithm) enables predictive maintenance, proactive planning, and continuous improvement based on data-driven insights.
- Developed a hybrid algorithm to dynamically adjust production schedules in response to unexpected disruptions or changes in demand.
- Successful implementation and integration of an automated production planning and control device with existing manufacturing execution systems (MES) and enterprise resource planning (ERP) systems.
- The economic benefits of implementing automated production planning and control devices in terms of reduced downtime, optimized resource allocation, and increased productivity.
- The user interfaces and design of the automated device was optimized to ensure ease of use and acceptance among production managers and operators.
- The automated system enhanced traceability and compliance with industry standards and regulations through automated record-keeping and reporting capabilities.

Statement of the Invention:

Historically, Production Planning and Control (PPC) was managed manually, relying heavily on human expertise and paper-based systems. The introduction of computerized systems in the late 20th century marked a significant shift in the management of PPC. Early systems, such as Manufacturing Resource Planning (MRP) and later, Enterprise Resource Planning (ERP) systems, played a crucial role in automating PPC by integrating various manufacturing processes (Lăzăroiu et al., 2022). But this developed system integrated the big data analytics models; the Seasonal Auto-Regressive Integrated Moving Average (SARIMA) for capturing linear trends and seasonality combined with Long Short-Term Memory (LSTM) network for capturing non-linear patterns and dependencies, for its Time Series forecast models, an IoT device for real-time monitoring and tracking of the inventory level and for real-time feedback of the system and production planning mathematical models for the scheduling of the product-

mix.

Summary of Invention:

An automated production planning and control device, is presented. This innovative research presents the activities carried out in the design development and implementation of an Automated Production Planning and Control Device (APPCD) applicable to manufacturing organizations, using a textile company in Lagos, Nigeria for practicability. Data of a five-year period starting from 2019 to 2023, broken down into twelve (12) months of each year were authorized by the textile company for collection but the display of the company's name was unauthorized. The data collected for the five-year period were production quantities of different orders collected by the company, the production quantities of the company's six (6) different products which were, Atiku, Expression, Collezione, Ultimate, Dobby and Plain, the raw material inventory and raw material production quantities, the production capacity of the company and the machine downtimes. The control system is designed to handle the forecast, material planning of the product-mix scheduling and scheduling of production planning and inventory control of the company. The design methodology adopted was the Structured System Analysis and Design Method. The design was achieved using PHP language and MySQL as the database file. Time series forecasting principle was adopted using a hybrid model of Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and Long Short-Term Memory (LSTM) network. The novelty of this innovative research is the integration of an IoT device to the developed system which can provide both visual and audio display of a real-time feedback on the raw material inventory, automated monitoring and forecasting of the production, a real-time production level display 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.

Claims

The claim of the invention is as follows:

1. The development and implementation of an automated production planning and control device.
2. A system as in claim 1, that can transmit data through web server and store data in its database with the help of an internet connection.
3. A system as in claim 1, that can either be integrated into an existing platform or perform independently to make a more accurate and precise production forecast.
4. A system as in claim 1, that can track and monitor the raw material inventory and sends real-time feedback through an IoT device.
5. A system as in claim 1, that can plan production schedule and also schedule the product-mix.
6. A system as in claim 2, the stored data can be generated from the database to forecast future production.
7. A system as in claim 2, the stored data can be generated from the database for the schedule future production runs and product-mix.

Diagrams

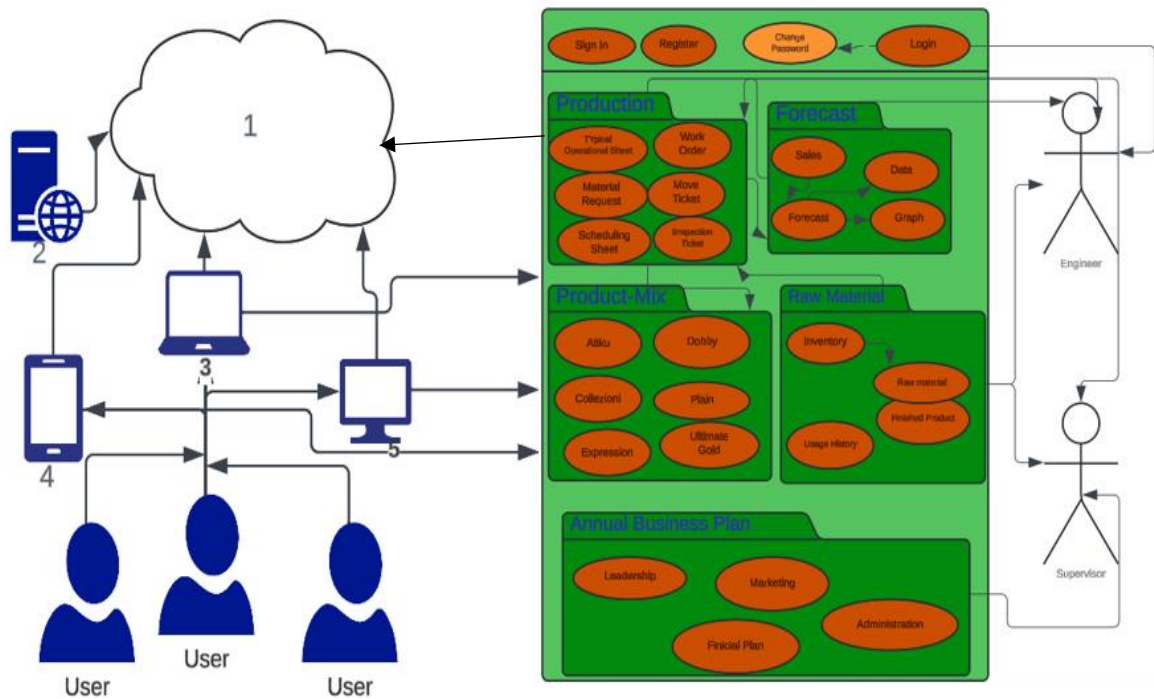


Figure 1: Automated Device for Production Planning and Control

Brief Description of Drawing

1 = IoT Device/Data Storage System

2 = Web server/Internet

3 = Laptop

4 = Mobile

5 = Desktop

In figure 1, the actors of the system are the management personnels like sales manager, and other managers, the plant supervisor, the production engineer(s), the engineers, the inventory manager(s), and the store keepers. The IoT device is attached to the company's data storage system, for control, for monitoring and for real-time feedback. The system is hosted with the web server for prompt update and response. The real-time feedback both audio and visual display, monitoring and controlling of the inventory both raw material inventory and finished product inventory can be assessed through laptops, desktops or mobile phones via the web server/internet.

The IoT device extracts sales data information from the finished product inventory stored in the database, and because of large volume of data available, the system uses a hybrid algorithm (SARIMA and LSTM) to forecast the production and also schedule for the production including the product-mix. From the UML use case part of the drawing, it can be observed that there is high level of monitoring and control of the system from the raw material inventory to production and scheduling to inspections and back to the finished product inventory. And all these information are being extracted by the IoT device in real-time.

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