POWER DISTRIBUTION NETWORK AND PRODUCTION CHAIN ANALYSIS IN AN INDUSTRIAL COMPANY

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Abstract
The efficiency of an industrial company's power distribution network and production chain is crucial for optimizing operational performance and minimizing costs. This study analyzes the intricacies of power distribution networks and the production chain within an industrial setting focusing on identifying key factors affecting energy efficiency, reliability and system resilience. Using a combination of data analytics, network modeling and process flow evaluation, the research investigates how power distribution impacts production throughout and operational stability. Furthermore, it explores potential improvement to energy management and highlights the importance of real time monitoring and predictive maintenance in minimizing downtime and ensuring continuous, reliable operations. The findings after actionable insight to enhance decision making, reduce energy cost and support sustainable industrial growth. Research methodology included a combination of secondary research with a literature review and analysis of primary data collected through surveys. The findings of the study revealed that power distribution is essential to the company operations, and the current power infrastructure requires attention. This project offers a comprehensive analysis of the power distribution network, unearths the problems that this company faces, and provides recommendations that can enhance the reliability of electricity distribution and, in turn, the production chain. The research recommends investments in modern power infrastructure and the adoption of energy-efficient practices to enhance production chains and ultimately reduce energy costs.

Keywords: Power distribution, Production chain, Industry, Network, Operational performance

Introduction

The power distribution network and production chain are critical components of any industrial company. Stable power supply ensures a smooth running of operational processes and limits the occurrence of operational delays and frequent damage to either the machines or finished products. The power distribution network provides the electrical power that is needed to run the production chain, while the production chain converts raw materials into finished products.

Power distribution is the vital infrastructure in modern economies that powers various industries, including manufacturing, transport, and healthcare. In Nigeria, power distribution challenges are among the major hindrances to economic development, with widespread power cuts and inadequate power supply. Research conducted in Nigeria shows that power cuts remain a hindrance to business growth, reduce productivity, and increase operational costs. A study conducted by Oyelade and Oludele (2018) on the effects of power outages on manufacturing output in Nigeria found that power outages reduced the number of workers in the industry by up to 60%. As a result, the reduction leads to a decline in manufacturing output. Moreover, power outages have a significant negative impact on small and medium-sized enterprises whose operations rely largely on electricity. Therefore, it is essential to address the challenges associated with power distribution systems for efficient and sustainable business operations.

Previous studies have identified technical problems such as inadequate maintenance, outdated infrastructure, and lack of investment as causing the frequent power outages in the country. Other literature explored alternative energy sources such as solar and wind energy and their potential to address Nigeria's electricity crisis. Further research recommended that the Nigerian government should prioritize investment in power infrastructure and alternate energy sources to enhance the country's power distribution

This report aims to analyze the power distribution network within Superflux International Limited, a printing and Production Company and the impact of this on the company production chain. The report will examine the key elements of the power distribution network, the company's infrastructure and recommendations for improvement.

Superflux International Limited is a leading printing and production company located in Ojodu, Lagos State, Nigeria. The company has a printing factory where sensitive materials like degree certificates, bank cheques, tickets, etc. are printed using high-end printing machines under strict security regulations. The company also carries out commercial prints, variable data prints, envelope production, thermal/POS roll production and others. Due to the sensitivity of the company's production, steady power supply for smooth machine operation and proper personnel management are areas of high priority in the day to day running of the company.

The company commenced operations in 1998 in the marketing of security prints products and has since grown from a 2-man trading company at inception to about 300 employees in a purpose built ultra-modern manufacturing facility.

Over the years, Superflux International Limited has become the leading cheque provider in Nigeria, accredited by the Central Bank of Nigeria, Central Bank of Zambia and West Africa Monetary Zone. They produce a wide range of cheques incorporating leading edge security features which gives documents maximum protection against fraud. The cheques are produced in different sizes and can be finished as cut sheet, flow line or multi-part variants.

With expertise and experience garnered over the years in security printing, they are able to create vibrant designs to meet specific clients' security and creative requirements. The cheque printing and finishing activities conform to established quality standards to guarantee

integrity in their processes and procedures. Superflux International Limited has also become a conglomerate with interests in courier and logistics services in Nigeria and Kenya with a subsidiary operating as an agro-allied business. The sensitive nature of its operations means visits into the factory are limited to only approved personnel and members of staff are diligently searched when going in and out of the factory premises. A well robust CCTV coverage of the entire company premises exists to aid proper surveillance and monitoring.

Power Distribution Network and Production Chain

One of the primary functions of industrial power distribution is to efficiently and reliably power the equipment and machinery essential for manufacturing and production processes. Industrial facilities rely on a vast array of equipment, ranging from motors and pumps to conveyor systems and robotic arms, all of which require a steady and uninterrupted supply of electricity to operate effectively.

Industrial power distribution systems ensure that each piece of equipment receives the appropriate voltage and current required for optimal performance. This involves managing power quality to minimize fluctuations and disturbances that could affect equipment operation. By maintaining stable voltage levels and mitigating issues such as voltage sags, surges, and harmonics, power distribution systems safeguard equipment from damage and ensure consistent production output.

Furthermore, industrial power distribution systems play a crucial role in load management, balancing the electrical load across different circuits and phases within the facility. By distributing the load evenly, these systems prevent overloading and voltage imbalances that could lead to equipment failures or disruptions in production. Effective load management optimizes energy usage and maximizes the efficiency of electrical infrastructure, ultimately reducing operating costs and improving the overall performance of industrial operations.

In essence, industrial power distribution systems serve as the lifeline of manufacturing and production facilities, powering the equipment and machinery that drive productivity and profitability. By providing reliable and efficient electrical energy to support industrial processes, these systems enable businesses to meet production targets, maintain competitiveness, and adapt to changing market demands effectively.

The power distribution network in this printing company comprises various components, including transformers, switchgears, distribution panels, diesel generator and electrical cables. The network is responsible for transmitting and distributing electrical power from the main power source to different sections and equipment within the factory facility.

Transformers: Transformers step up or step down the voltage to ensure efficient power distribution. They help match the voltage requirements of different equipment and sections within the factory. A 500kVA transformer steps down the incoming 33kV line from the National Grid to 400V for use in this factory. This transformer is the primary link between the factory and the National Grid.

Switchgears: Switchgears are used to control and protect the power distribution network. They isolate faulty equipment and prevent

electrical failures from affecting the entire production chain. Switchgears also facilitate maintenance and repairs. Every section in the factory has switch gears to either isolate a series of similar machines or similar equipment.

Distribution Panels: Distribution panels receive power from the switchgears and distribute it to various sections or production lines within the factory. They contain circuit breakers and fuses for overload protection and to ensure the safe operation of equipment.

Electrical Cables: Electrical cables connect the distribution panels to the equipment and machinery in the production chain. They carry the electrical power required for the operation of the different processes, ensuring a smooth and uninterrupted flow.

Diesel Generator: A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. It is a combination of a diesel engine with an electric generator to generate electrical energy. A diesel compression-ignition engine is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas. Due to the epileptic supply of power from the National Grid, the diesel generator serves an alternate source of power for this company. More often than none, the diesel generator runs nonstop even when there is power supply from the Grid. This is to prevent disruptions in the printing of sensitive materials due to the unstable nature of electricity from the National Grid.

Production and printing operations are done round the clock, therefore, employees in the operations section operate in shifts to maximize output and efficiency. The company operates over 30 industrial standard printing and production machines and equipment. These include intaglio printers, flexographic printers, offset printers, packaging machines, die cutters, check cutting/encoding machines, forklifts, pallet jack and others.

The typical flow of activities includes marketing and advertisement of services to prospective clients. Upon job or contract acquisition, design samples and prototype prints are sent to the client for verification and confirmation. After due consultations with the client on modifications, the printing process eventually begins. Sample structure and specification is loaded onto the systems for onward production. Depending on the nature of the job, each machine has its own configuration based on expected outputs. After completion of expected orders, output is packaged and either picked up or sent to the client.

The company's pricing policy is dependent on the job type, volume of output and cost of production.

The production chain for this printing company can be broken down into the following primary activities:

Inbound logistics: This includes activities such as purchasing raw materials, storing them, and transporting them to the production facility. All materials are safely kept in the factory storage unit and is only accessible by specified members of staff.

Operations: This includes the actual printing process, as well as any post-printing operations such as cutting, folding, and binding. Jobs are classified and scheduled to various machines based on type, specifications and expected delivery dates.

Outbound logistics: This includes activities such as storing finished products, packaging them, and shipping them to customers.

Marketing and sales: This includes activities such as generating leads,

developing marketing materials, and closing sales.

Service: This includes activities such as providing customer support, reprinting damaged products, and recycling waste.

In addition to these primary activities, there are also a number of secondary activities that are important to the success of this printing company. These secondary activities include:

Procurement: This includes activities such as finding and negotiating with suppliers, as well as managing the supply chain.

Technology development: This includes activities such as researching new printing technologies, developing new printing processes, and training employees on new technologies.

Human resource management: This includes activities such as recruiting and hiring employees, training and developing employees, and compensating and rewarding employees.

Infrastructure management: This includes activities such as maintaining the printing facility, managing the printing equipment, and ensuring the safety of employees.

The production chain for this printing company can be complex and challenging to manage. However, by understanding the different activities involved in the production chain, the company can further improve their efficiency and profitability.

Here are some of the key factors that can affect the efficiency of the company's production chain:

The quality of the raw materials: The quality of the raw materials used in the printing process can have a significant impact on the quality of the finished product. High quality papers can affect the appearance and resolution of prints, security tags and watermarks are highly sensitive and can be best implemented when the quality of ink and paper being used is of good standard.

The efficiency of the printing equipment: The efficiency of the printing equipment can also have a significant impact on the production time and cost. Lags and incessant jams in the rollers of the printing machines can lead to an increase in damaged outputs and delay in job completion. The company has engineers who operate round the clock in the maintenance and repair of all factory machines. This sustains smooth operation and quick troubleshooting of issues that may occur during the production process.

The skill level of the employees: The skill level of the employees who operate the printing equipment can also have a significant impact on the quality and production time of the finished product. Every employee in the operations department undergoes a supervised training process before to assess their responsiveness and ability to operate the machines without hindrance.

The layout of the production facility: The layout of the production facility can also have a significant impact on the efficiency of the production chain. Security printing jobs like bank cheques and ballot papers are done in a section separate from commercial prints and envelope productions. The factory basically has three layers; The lowest layer is for envelop and Thermal roll productions, Middle layer is for commercial prints and the top layer is for sensitive printing jobs.

The use of automation: The use of automation can help to improve the efficiency of the production chain by reducing the amount of manual labor required. All machines require minimal human interference, print schedules, design and other adjustments are made on the system

therefore, the machines print, cut and produce to set specifications. Security watermarks and numberings are all automated on the machines.

Methodology

This study employs a mixed methods approach to analyze the power distribution network and production chain in an industrial company focusing on data collection, system modeling, and performance assessment.

Data Collection

Data on power consumption production rates, maintenance records, and downtime events will be gathered from historical records SCADA (Supervisory control and Data Acquisition) systems and energy management software used within the company. Survey and interviews with technical staff and operators will provide additional insights into challenges and inefficiencies.

Power Distribution Network Analysis

A comprehensive evaluation of the power distribution network will be conducted using network modeling tools such as ETAP (Electrical Transient and Analysis Program) or similar software. This step includes:

Load Flow Analysis: Evaluates power distribution at each node to determine area of overload or inefficiency

Fault Analysis: Identifies potential fault locations and assesses network resilience in case of component failure.

Reliability Analysis: Analyzes historical fault data to calculate metrics like SAIDI (System Average interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) to assess reliability and plan for improvements.

Production Chain Analysis: The production process will be mapped and time-motion studies will be conducted to identify bottlenecks and production inefficiencies, key methodologies include:

Process Mapping: Detailed mapping of the production chain from raw materials to final product, identifying key stages and energy intensive processes

Value Stream Mapping: Analyzes flow efficiency by focusing on material flow, cycle time, and lead time.

Simulation Modeling: Using software like Arena of Any logic, a simulation of the production chain will be developed to test potential improvements in throughput and efficiency.

Energy Efficiency and loss Analysis

Using Collected data the study will evaluate energy losses within the power distribution network and production chain Specific areas of include:

Power Quality Assessment: Voltage Fluctuation, harmonics, and power factor issue will be analyzed to determine impact on equipment performance and Energy use

Thermal Imaging: Infrared thermal imaging will be used to identify overheating overheating component within the distribution system.

Energy Balance Analysis: An assessment of energy input versus otput at each production stage to identify waste and inefficiencies.

Predictive Maintenance Model

A predictive maintenance model will be created using historical data on equipment failure and operating conditions. Techniques such as machine learning algorithms (e.g., decision trees or neural networks) will be employed to predict the likelihood of failure and optimize maintenance

schedules, reducing unplanned downtime

Cost-Benefit Analysis
Finally, a cost-benefit analysis will be conducted to quantify the potential saving from implementing the recommended improvement. This will include consideration for reduces energy cost, improved production efficiency, and reduced downtime.

Data Analysis Techniques
Quantitative data will be used statistical software such as SPSS or R, with a focus on regression analysis to understand the impact of power reliability on production. For qualitative data from interview, thematic analysis will be used to identify recurring patterns in employee insights.

Electrical System Analysis
A complete analysis of the electrical system in the company was carried out to assess the various components and determine its reliability and efficiency.
Load Analysis: The Company is basically sectioned into two - Administrative Building and Factory Building. All electrical loads such as machinery, lighting, HVAC systems and office equipment within both buildings was identified. The usage patterns of these electrical loads were also captured. The table below shows a summary of the energy demand in the company.

	Lighting	**Office Equipment**	**Machinery**	**HVAC System**	**Total Load**
Administrative Building	2.2kW	5.8kW	-	12.5kW	20.5kW
Factory Building	1.6kW	0.5kW	250kW	20kW	272.1kW
					292.6kW

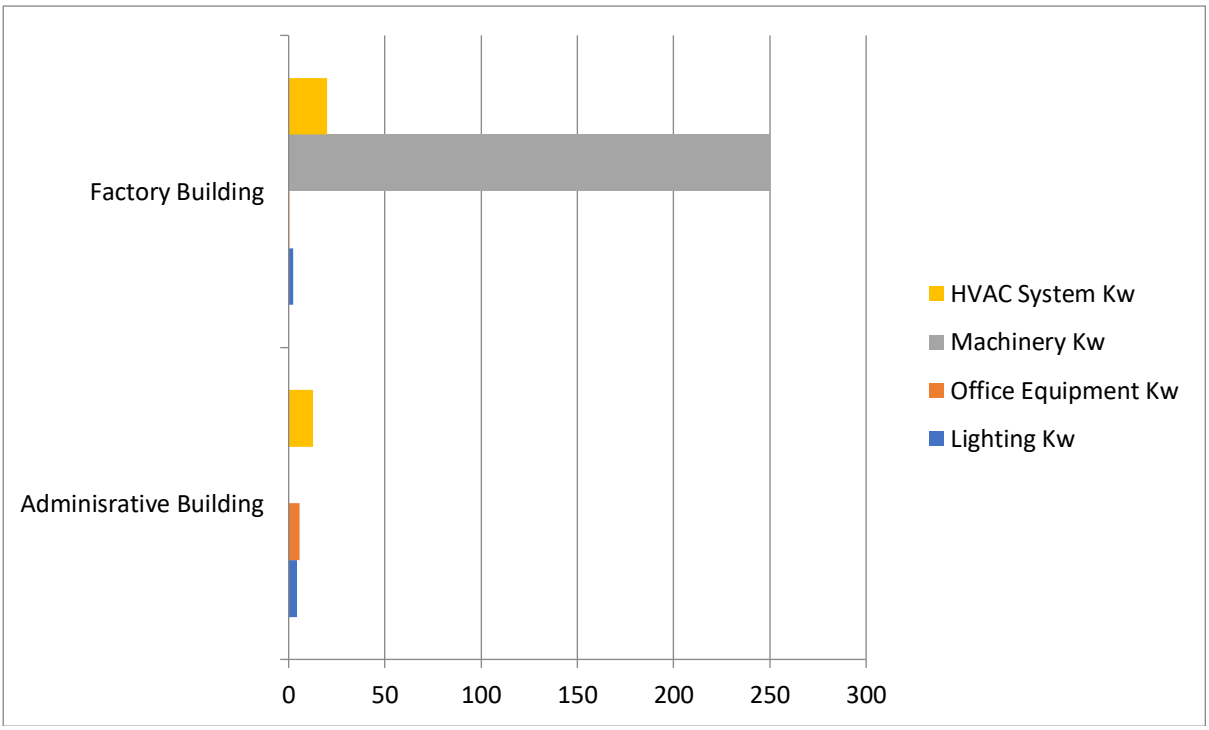

Figure 1: Bar chart on the Load Analysis of the Company

Category-wise load Comparison
Lighting Load
Administrative Building: 2.2kw (10.7% of total load)
Factory Building: 1.6kw (0.6% of total load)
Lighting usage is relatively higher in the Administrative Building compared to its total load
Office Equipment Load:
Administrative Building: 5.8kw (28.3% of total load)
Factory Building: 0.5kw (0.2% of total load)
Office equipment usage is significantly higher in the Administrative Building.
Machinery Load:
Administrative Building: 0kw (0% of total load)
The factory has a much larger machinery load, which is expected due to its primary function.
HVAC System Load:
Administrative Building: 12.5kw (61% of total load)
Factory Building: 20kw (7.4% of total load in the Administrative Building but a smaller portion in the factory.
Total Load Comparison
Administrative Building: 20.5kw
Factory Building: 272.1kw
The total load in Factory Building is considerably higher, driven primarily by machinery
Proportion of Usage by Category
Administrative Building has a more balanced distribution, with lighting, office equipment and HVAC contributing significant portion to the load.
Factory Building's load is heavily concentrated in machinery, with other categories contributing very small portions.
Efficiency Improvements:
The administrative building could consider energy saving measures for HVAC and office equipment as they contribute the most to its total load.
In the factory, machinery dominates the load, so optimizing machinery energy use could lead to significant reductions.
Usage Patterns:
The administrative building primarily consumes energy in office related categories (office equipment and HVAC)
The factory's high machinery usage suggests it's dedicated to industrial processes, with less emphasis on lighting and office equipment.
Voltage Levels: This varies as some machines in the factory are three-phase systems while some are single-phase power systems. A multimeter was used to ascertain this to correlate with installations setups and schematic diagrams of every equipment. Every component in the administrative block runs on a single-phase power system.
Earthing/Ground System: An analysis of the earthing system in the factory was conducted and it was discovered that overtime the earthing system of the factory has depreciated and this could result in harm to operators and damage to machinery.
Power Quality: Volage stability, harmonics and transient voltage surges analysis was carried out to establish power quality as this is crucial to equipment functioning. During the study, no voltage instability was discovered as the factory runs on diesel powered generators round the clock.
Electrical Wiring: The general condition of cables and wires in the factory was satisfactory.
During analysis, some issues were identified in the company's production chain and power distribution network. These issues include:

Lack of monitoring and control: The absence of real-time monitoring and control systems makes it challenging to detect and address power distribution issues promptly. This can result in delays in identifying faults and increased downtime.

Aging Infrastructure: Aging components and infrastructure in the company's power distribution network resulted in power interruptions and posed safety risks. Some factory machines are outdated and consistently develop faults during operations which in turn affects product delivery schedules.

Cost of production: Due to the company's reliance on diesel generators for consistent power supply, there is an increase in operations and maintenance costs. This subsequently increases pricing and reduces the company's yearly revenue.

Staffing: Finding and keeping qualified staff is a challenge for this printing company. This is due to the high turnover rate in the industry and the demanding nature of the work.

Technology: The printing industry is constantly evolving, with new technologies being developed all the time. This can make it difficult for printing companies to keep up with the latest trends, which can lead to business losses.

Energy Efficiency: The energy efficiency of the company can be greatly improved due to the type of lighting systems and old machinery currently in use.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

- The company should consider alternative sources of renewable energy, such as solar or biomass to supplement electricity from the National Grid and reduce dependence on diesel gensets.
- The company should consider adopting energy-efficient practices like upgrading lighting systems to LED fixtures and optimizing or replacing older machines with new energy efficient alternatives. This will help lower electricity consumption and reduce operational costs.
- Improve the management of employees by building their entrepreneurial capacity to shape the organization's productive chain.
- Develop a regular maintenance plan for existing power infrastructure
- Conduct a comprehensive assessment of the power distribution and production infrastructure thereby prioritizing upgrades or replacements for aging components and machines. This may involve replacing old machines, upgrading distribution cables, and installing modern electrical panels.
- The company should conduct regular assessments of power demand and ensure that the power distribution network has sufficient capacity to handle current and future requirements. Consider factors such as expanding production capacity, introducing new equipment, or incorporating renewable energy sources.
- A centralized monitoring and control system that provides real-time data on power distribution parameters should be implemented. This will enable proactive identification of faults, prompt response to outages, and better management of the overall power distribution network.

- Training programs for staff members responsible for power distribution to enhance their understanding of the network and equip them with troubleshooting skills. Additionally, establish a robust preventive maintenance schedule to ensure regular inspections, repairs, and replacements of critical components.

Conclusion

This report captures the important sectors and activities in Superflux International Limited. The power distribution network plays a vital role in the production chain of this company, ensuring its reliability and efficiency is crucial for uninterrupted operations. By addressing some of the issues captured and recommendations offered, the company can enhance its productivity and improve the resilience of its power distribution network.

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