RESEARCH IN LOGISTICS & PRODUCTION

DEVELOPMENT OF A FLEXIBLE PROCESS LAYOUT FOR A NIGERIAN BEVERAGE INDUSTRY

Buliaminu Kareem*, Peter Kayode Oke** and Ayodele Salami Lawal***

* Department of Mechanical Engineering, Federal University of Technology, P.M.B. 704, Akure, Ondo State, 34001, Nigeria, Email: karbil2002@yahoo.com
** Department of Mechanical Engineering, Federal University of Technology, P.M.B. 704, Akure, Ondo State, 34001, Nigeria, Email: okekayode2002@yahoo.com
*** Department of Mechanical Engineering, Federal University of Technology, P.M.B. 704, Akure, Ondo State, 34001, Nigeria, Email: lawal_salam@yahoo.com

Abstract Product design is changing everyday as a result of changing in taste of the customers. Production layout must be flexible to cater for these changes. Production layout is flexible if it can accommodate change in flow of workers, material and machines in compliance with the new product demand. In this study, flexible process layout was developed for a Nigerian beverage industry to take care of future change in product design. In the industry, flexibility was considered in redesigning of old production layout in the areas of industrial facility, and operational planning. It was discovered that old layout was deficient in the area of flexibility by 90% of the set standards of the criteria for plant layout. The findings have indicated that the flexibility in plant layout is cardinal in combarting the challenge of changing industrial environment.

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1. INTRODUCTION

A smooth manufacturing process can be achieved if the plant layout is flexible in flow of workers, materials and machines. This flexibilty can bring about desire goal of minimising production cost with little or no industrial accident. Many industries today are recognized because their products are in high demand and in large quantity in the market. In these industries there is good relationships among staff, managements and the located communities. Within the industries there are fewer or no record of accidents. Jobs are done comfortably. There is enough working space for various machines, facilities and the employees. They enjoy a safe and comfortable environment during work. Any industry that is operating under aforementioned conditions will surely be profitable. All these and more are the dividends of a carefully planned production layout.

In a well planned layout, plant's facilities are properly arranged, in such a way that there are little or no interference among jobs. This will help management to use funds judiously in the area of employment of staff, purchase of raw materials and procurement of machines. Also, a careful plant planning aids in utilizing effectively the floor space of organization for maximizing profit. These arrangements also improve manufacturing process, reduce material handling and maintain high turnover of work-in-process with a minimum cost. In developing countries such as Nigeria, many industrialists have not utilised the opportunity of installing a flexible plant layout for optimal output, instead, many of them are still familiar with the rigid traditional layout designed for a product of predetermined output. The area of focus of this paper is to develop a plant layout for a beverage industry with flexible flow of manpower, material and machines.

The elements of plant layout were widely discussed in literature. Plant layout is a plan for the effective arrangement of the physical facilities and manpower for the manufacture of the products (Apple, 1977); (Crow, 2002). It brings together and fully integrates all the efforts that have been carried out by the architect, the production engineer, the process engineer and the management in their careful planning for the production of goods in an optimum manner. Plant layout covers the planning of space requirements for all activities in an industrial firm including offices, warehouses, room, and all other facilities associated with the total manufacturing plant (Sullivan, Bontadella & Wicks, 2000).

A plant layout should be planned (Apple, 1977) to: minimize material handling; maintain flexibility of arrangement and operation; maintain high turnover of work-in-process; hold down investment in equipment; make economical use of building cube; promote effective utilization of manpower; and provide for employee convenience, safety and comfort in doing the work.

Plant layout extends to planning of: external transportation facilities; operations (unloading, inspection, stores); production activities; material handling; service and auxiliary operations; quality controls and inspections areas; packaging operations;

storage operations; shipping operations; and offices. Plant layout is affected by: product; volume or rate of production; quality; equipment; building; plant site; material handling; and equipment layout. These aforementioned influencing factors demand a plant layout which is flexible and capable of accomodating an unexpected change in product design (Steveson, 2005); (Jewo, 2009). However, the modification to the old plant layout to take new shape (for new product) must be economically justifiable.

Good material flow and a sound material handling system are basic to economical production (Payne, Chelsom & Reavill, 1999); (Riggs, 1982). Plant layout's specifications for the material handling equipment aids in planning for provision for adequate aisles for movement of materials and the allocation of space for storage. Equipment plans for layout are mainly divided into two broad groups namely process, and product layouts. The combination of these groups of layouts is also used in some manufacturing industries. The choice of layout type to be deployed largely depends upon many factors including the types of products to be manufactured. Process layout is characterised by intermittent manufacturing and the product layout is most common in continuous manufacturing. However, with current trend towards automation, the future may lead to more product layout factories. Flexibility is requied in process layout because of: need for a skilled labour force capable of doing variety of operations; many production orders in process at any time; frequent movement of materials between operations and department; extensive storage space in departments for unprocessed materials; considerable storage space around machine; high inventories of in process materials; general purpose material handling equipment; much scheduling of and careful control of materials in process; and a lack of mechanical pacing of work. Process layouts are common in jobshops

Product layouts are associated with mass production of goods such as automobiles, refrigerators, and washing machines. If the plant layout activity in a manufacturing plant is to be effective, there must be a well-defined responsibility for its accomplishment. Plant layout is a planning activity headed by a plant layout engineer or an industrial engineer. Thus, if process change is anticipated owing to model changes, new products, technological improvements, or other causes, it is the responsibility of plant layout group to redesign the layout in order to meet these challenges. The study on the assessment of production layout of a brewery factory has been carried out (Kareem, Oke & Lawal, 2011). The study by Kareem and others (2011) has limitation in the area of estimation of flexibility of the proposed plant layout. The current study relaxes the limitation of the past work by establishing flexibility in the newly designed plant layout for a Nigerian beverage industry. The rest of the paper is presented thus: materials and methods are presented in Section 2. Section 3 hosts results and discussion, while conclusion is presented in Section 4. Lists of references, and biographical notes, end the presentation.

2. MATERIALS AND METHODS

This study uses a Nigerian beverage industry as a case study and compares the equipment layout and location of various facilities of a standard plant layout structure to that of the industry. Based on this, a new process layout which is flexible is developed to replace the old and rigid layout. Data were collected from the industry through questionnaire administration and direct interview, while that of the standard plant layout structure was obtained from the literates. Many industries follow different procedures to face plant layout challenges. The proce-dures followed in this paper in arriving at an economic plant layout of the beverage industry are: data accumulation; data analysis and coordination; product flow pattern; work station layout; material handling; and floor/physical facility plans. Data needed for various processes of manufacturing the product; tools and equipments required are collected from all sections of the beverage manufacturing organization. These data will aid in creating a new process flow chart for the manufacturing of the product. From this plans, equipment list and specifications will be made based on available floor space.

Careful analysis and coordination of the basic data aid to determine: total number of employees required; total number of work stations to be planned for; the kind, size and number of every piece of equipment that is accommodated in the layout; and total space required for storage of inventories including raw materials, work-in-process and finished goods. For a process layout, the general pattern of flow for the product, would involve arrangement of the various functional depar-tments in the manufacturing process. In process layout, each workstation or pro-duction centre is laid out for the most effective performance of its operation, taking into account space for storage of tools and material, ease of maintenance of equip-ment, workers safety and comfort. A good plant layout makes room for efficient material handling. The selection of an effective material handling equipment contributes towards arriving at the optimum layout of the manufacturing facilities (Aderoba, 1995). The maintenance of up-to-date layout of a factory requires effective communication among all manufacturing functions. The identified standard principles adopted in implemeting the stated procedures in the beverage industry are: move materials within minimum distance; avoid or minimize the back tracking of materials; plan for a minimum material handling; use manufacturing space econo-mically; permit all flexibility possible; and allow for possible plant expansion.

It is difficult to evaluate which plan will represent the best layout, but it is widely known that the best plan is the one that produces optimum output of product with a minimum manufacturing space (Adroba, 1995, 2005). However, to measure the effectiveness of the layout by plant arrangement alone can hardly be accepted as conclusive. Analysis of material handling involved is another possible measure of layout effectiveness. Thus, one may be tempted to say that the layout with minimum material handling of materials is the best. On the other hand, this layout might be costlier in equipment and installation. New quantitative tools such as

simulation and computer program are being developed to determine the optimal plant layout (Pressman, 2005). This development point out the most effective methods of evaluating alternative designs of plant layout. With this, the proposed plans are tested at relatively low cost (Kailash & Ruddell, 1972). In this study, the identified plant layout critieria are subjectively tested in sequence, and the deficient criteria (from the standards) are meticulosly incorporated into the newly developed flexible plant layout.

3. RESULTS AND DISCUSSION

3.1. Proposed plant layout

The diagrammatic representation of the beverage industry's plant in Nigeria is shown in Fig. 1. A careful study of this layout shows that the layout planning covers: external transportation facilities; receiving operations (unloading, inspection, stores); production activities; material handling; service and auxiliary operations; quality controls and inspections areas; packaging operations; storage operations; shipping operations; and offices. The beverage industry produces three types of bottle drinks. They are Malta Guinness, Guinness stout and Maltonic. The plant has six lines of production and all work at the same time except for cases where any line may be shut-down for maintenance purpose. Workers usually work in shift as production occurs during the day as well as the night. Quality-wise, the drinks produced are usually obtained by first mixing the necessary ingredients. These are later chilled and carbon dioxide is bubbled in. Pasteurization is the last process of production of the drinks. All necessary equipment for production, material handling and service are available to the company's required specifications. The administrative buildings are located far from the noisy area of the production zone. The machine shop, generator, and the line locations are all enclosed by large tall buildings.

For plant site, the brewery is located at express double-lane roads. There are good network of roads around the complex and the surrounding community is very friendly. Areas of residence around the plant comprises the motor parks, and the federal housing estates. Worthy of note are constant supply of electricity and water, good schools, religious centres, broadcasting/media houses and recreational centres are available around the plant site. Most importantly, the waterbed is not too far into the ground and thus water is available because it is an important consideration for the plant's choice.

Safety standard is highly implemented in the beverage factory. Thus apart from safety rules, there are security operatives and fire fighter/operations services are available. Facilities are well located to prevent heavy work areas having interaction with clerical and office work (Armstrong, 2006); (Telsang, 2004). There is a clinic

at hand within the premises of the organization. This is available to give first aid in case of any accidents. The layout of staff is taken in great consideration. Food is provided twice daily for staff. Good office environment with cleaners available to clean the office, and good office equipment and air conditioning, packaging halls, workshop, plant houses and production floor. Well ventilated and cleaned safety gadgets are provided to the various staff when needed depending on job type (Blunt & Popoola, 1995); (Kareem 2005). The material handling of product and goods are done with inadequate material handling equipment. Transfer of crates of bottles from trailers, washing, filling and corking of bottles, and tranfer of corked bottles to packaging and storage room were achieved by material handling equipment like fork lift, trucks and conveyor system. Fig. 1 shows locations of various facilities in the work stations. Those facilites that are closely related to one another are rigidly located together, and those that are not related are far part. Sensitive areas to which accidents can have a devastative effect are far from areas that may result in such accidents.

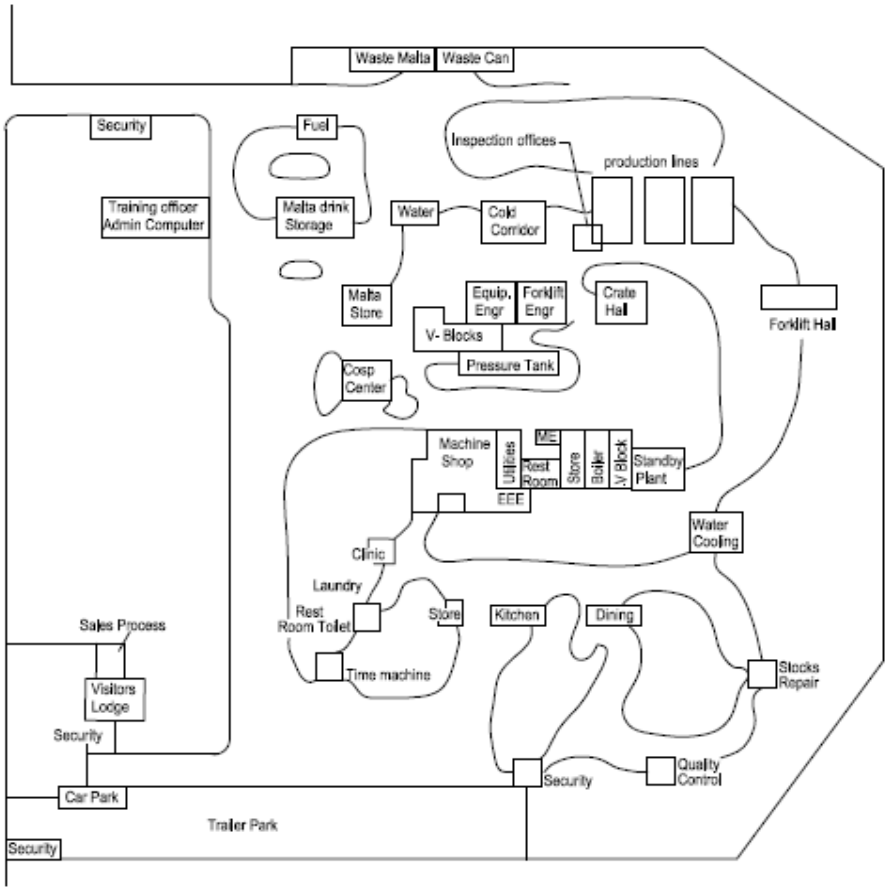

Fig. 1 Conventional (old) beverage plant layout

Fig. 2 shows a proposed complete-breakdown of movement pattern of the production process. From the figure, it can be observed that products are moved from one main workstation to the another, while some products from main workstations pass through substations. For example, before filler operation, ingredient extraction, mixing, cooling and addition of carbon dioxide must take place, the pressure from the boiler is needed to rotate the filler. Flexibility is considered in the new plant layout through provision of design plan for effective material handling equipment and other arrangments that would facilitate efficient flow of manpower, materials and machines. The new plant layout would eminently accommodate the processing of the new beverage product any time the change in taste of customers is witnessed.

3.2. Old plant layout and the Standards

From the results presented in Table 1, the old layout only meet 90 % of the standards if shipping criterium is considered. It can be seen that flexibility has been created in the old layout by providing arrangement for shipping. With this development, old plant layout of the beverage industry was upgraded to the newly developed standard plant layout. A further look at Fig. 2 shows that a trend of product layout occurs at the production floor, whereas, the machine shop and utility hall exhibit a process layout. It can be concluded that a combination of product and process layouts exist at the complex, from which the main production process utilises product layout. The newly designed layout has made provision for combination of product-process production system, hence flexibility is enhanced. In the newly developed layout, standard and tested products are brought from different quarters to management desk. The different quantity or volume of raw materials (malt, water, and other ingredients) to be used are collated and integrated with the necessary work pattern to ease conveyance, and processing of materials at different work-stations to bring about quality product (Fig. 2). The processing facilities are arranged in such a manner that facilities which are close related to jobs are brought together for easy interaction. The job then flows harmoniously to bring about finished material processing at the lines. The various workstations including service stations within the beverage are planned to attain effective performance of production lines. There available power station for providing stand-by power supply, boiler for pressure generation; each workstation has space for tools, overalls and other workshop gadgets. At the beverage factory, there are air pressurized automated machines which engage in loading and unloading of bottles on and off conveyors and trailers. Also available are conveyors, forklifts and trailers to ensure minimal material handling. Administrative areas are located at areas far from work zone. Offices around machine shops are located on the first floor. They are sound proofed and air-conditioned. Other floors/offices are the quality control and the chemical centre, they are located far from the machine floor. These floors are around the production areas and those of outmost important are closer to the production area. From this

new arrangement, agility is created in interaction among the various workstations and substations. Thus, the beverage factory has been upgraded to the status of standard layout.

The results of comparison between general principles of standard layout and that of the beverage company is shown in Table 2. For the beverage factory, due to rigid structures on ground, flexibility cannot be applied in all areas. Thus, the layout flexibility is restricted in some areas such as shipping facility. The plant layout of the beverage industry have good space management (Fig. 1). The manual labour of material handling system some years ago has been currently replaced by automoted material handling (Tab. 2). The material handling automation has saved cost of excessive engagement of workers. The profit obtained from using automated material handling equipment has covered the cost of these machines including cost of installation.

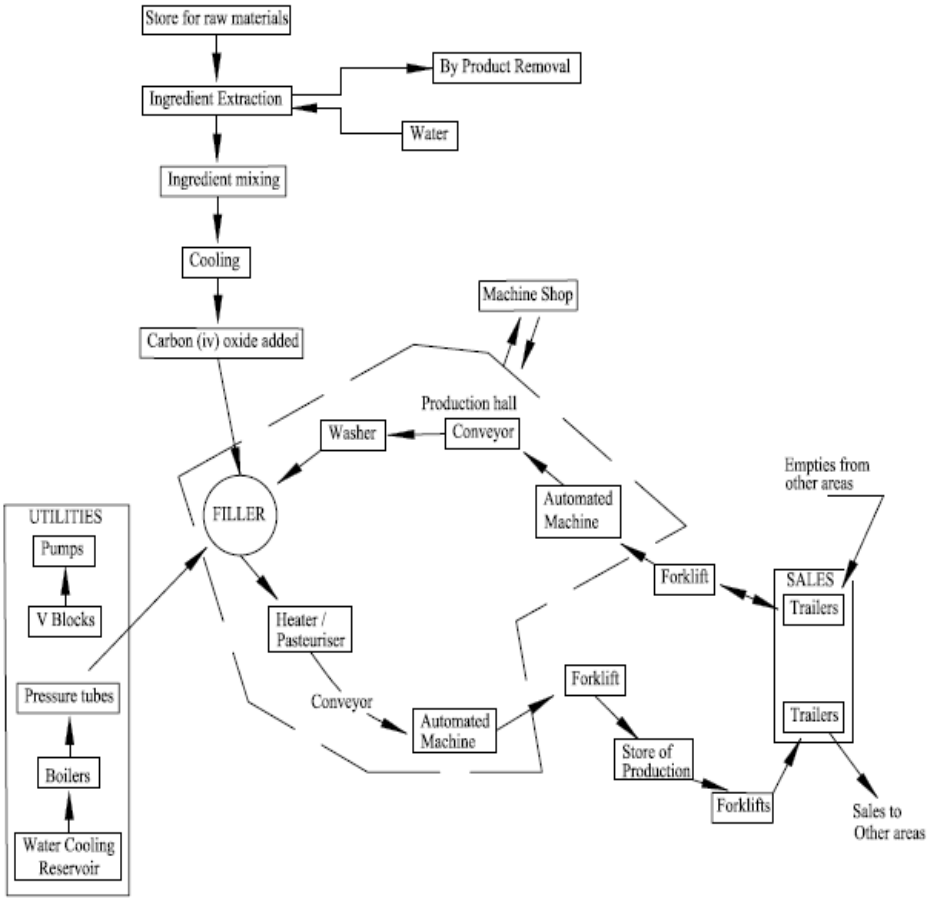

Fig. 2 Proposed plant layout for the beverage factory

Table 1 Beverage plant layout and the proposed standard

Criteria	Standard	Beverage plant
External transport facility	✓	✓
Receiving operations	✓	✓
Production activities	✓	✓
Material handling	✓	✓
Service and auxiliary operations	✓	✓
Quality control and inspection areas	✓	✓
Packaging operation	✓	✓
Shipping operation	✓	-
Storage operation	✓	✓
Offices	✓	✓
Total Score	10	9
% Score	100	90

Table 2 Principles of proposed standard layout and the beverage plant

General principles	Standard	Beverage plant
Move materials within minimum space	✓	✓
Avoid or minimize back tracking of materials	✓	✓
Planning for a minimum material handling	✓	✓
Use manufacturing space economically	✓	✓
Permit all flexibility possible	✓	-
Allow for possible plant expansion	✓	✓
Total Score	6	5
% Score	100	85

4. CONCLUSION

It was found from this study that there is a close relationship between the standard layout and that of the brewery industry used as case study. There is a close agreement of about 90 % between the beverage plant layout and the flexible standard. With the inclusion of shipping and flexibility arrangement, it can be concluded that the beverage industry has been upgraded to the standard plant layout.

In the new plant layout proposal, flexibility was created by providing the alternative routes that cater for the complexity that may arise from increased demand of product beyond the supply. There are too many trailers' congestion at the trailer park. Provision of alternative/mobile motor parks were proposed for solving this problem of congestion at the park. If there is no fund to construct these alternative roads and motor park, it is advisable to load the trailers sequencially based on non-interruptible schedule. Besides, several other routes can be taken to

prevent traffic congestion and accidents. From the outcomes of this study it can be concluded that flexibility in design of plant layout is necessary in the industries to meet the challenges of changing industrial environment.

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BIOGRAPHICAL NOTES

Buliaminu Kareem is a Senior Lecturer at the Federal University of Technology, Akure, Nigeria. He teaches engineering management courses such as Operations Research, Work Study, Production and Maintenance Management. His research interests are Industrial/Production Systems Design, Optimisation and Maintenance. He is a reviewer to many reputable journals including European Journal of Operational Reseach and Internation Journal of Management Science. His papers appear in numerous journals including Journal of Computing, Internet and Management, Thailand, and Journal of Applied Mathematics and Bioinformatics, Greece.

Peter Kayode Oke is a Senior Lecturer at the Federal University of Technology, Akure, Nigeria. He teaches production and operations management courses such as Machine Tools Management, Network Analysis, and Operations designs. His research interest is Industrial Systems Management. His papers appear in numerous journals including Journal of Applied Mathematics and Bioinformatics, Greece, and Nigerian Journal of Engineering Management.

Ayodele Salami Lawal is a Teaching Assistant at the Federal University of Technology, Akure, Nigeria. He holds B.Eng (Mechanical Engineering), and M.Eng (Production Engineering). He specialises in the area of Production System design and Maintenance management. His paper appears in journals including Journal of Applied Mathematics and Bioinformatics, Greece.