AN EVALUATION OF TECHNICAL AND ECONOMIC PERFORMANCE INDICATORS IN A POLYURETHANE FOAM MANUFACTURING INDUSTRY IN NIGERIA

[a]Jimoda, L.A; [a]Latinwo G. K and [b]Lawal N.A

[a] Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
[b] Faculty of Management Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Corresponding Author: gklatinwo@lautech.edu.ng

ABSTRACT
The work is aimed at investigating, analyzing and comparing the business performance before and after a polyurethane foam producing company embarked on Max foam plant, which is a continuous machine for producing foam as a result of technology development. The study was designed to assess the performance of the company using questionnaire, interviews as well as data from secondary sources. The current productivity of the company (1996-to date) was found to be much higher than hitherto (1979-1996) when it employed the older method of polyurethane foam production (the "box method"). The production rate per month, operating profit per month, operating profit per annum, the profit after tax, all increased tremendously by about 600%. Overall, the company achieved increased production, reduced wastage, high tonnage and reduced process and fugitive emissions. Strategies for maximizing the benefit of using the latest technology of production were therefore recommended.

Keywords: Batch process, Continuous Process, Polyurethane, Economy, SMEs, Technology Industry.

INTRODUCTION

As Nigeria started transiting away from oil boom, there were efforts and activities that could make Nigerians self-employed and employers of labour. Nigeria, as a developing nation, has for long explored and formulated policy structures and strategies to promote technology based small and medium scale enterprise growth and to offer a promising future within the global marketplace (Dutse*et.al*, 2013). This led to the emergence of several industries in Nigerian cities like Lagos, Aba, Kaduna, Port Harcourt and some parts of Osun State. One of such industries is the polyurethane foam industry. However, the industry suffers some basic inputs like capital, technical know-how, labour and organizational skills.

Technology is currently powering every facet of human endeavour, enabling effective governance, empowering security, driving economic and social changes (Lawal*et. al*, 2014).

Analysis of technologically advanced economies shows that at each level of the economy, science and technology provide the engine for economic growth (Egbogah, 2012). As a result of continuous researches and technology development, the process changes and production processes of foam production have changed considerably. The traditional batch method of production known as 'Box Method of Foaming' has been finally replaced by the 'Continuous Machine for Foam Production'. This has affected technical, managerial and economical running of the industry.

Polyurethane foam industries have in recent time replaced foams produced from natural and synthetic latex technology. This is not as a result of the fact that polyurethane structures give a tough molecule able to take high loadings, but also that it can be prepared to a much lower density than latex foam of the same load bearing capacity (Duke, 1971). Hence, polyurethane foams are cheaper and tend to find outlets in the lower quality furniture and automobile markets.

The technology of polyurethane foam is not of recent origin since urethane chemistry dated back to 1849 when reaction involving isocyanate and hydroxyl compound were first reported (Adedeji, 2001). However, urethane reaction had significance in laboratory in 1937 when a commercial use of di-isocyanate was employed by German chemist, Otto Bayer. By 1985, world manufacturing capacity for polyurethane foams had reached nearly five million metric tones located primarily in the North America and Western Europe (Overcash and Kaufman, 1993).

The advent of World War II and the subsequent shortage of rubber materials spurred the commercial development of urethane materials for such application as fibres, bristiles, adhesives, surface coatings, clastromers and foams. After World War II, the German technology became generally available, stimulating urethane development in the United State and elsewhere. The introduction of polyether to the urethane industry became a reality within a short time. Not only did polyethers have a cost advantage but they also produced foams with physical properties more desired than those made from polyester type polyol. In most foam industries in Nigeria, polyether foam is widely manufactured (Makanjuola, 1999a). The Table 1 below compares polyether and polyester foams;

Table I: Comparative Features of Polyester and Polyether Foams.

Feature	Polyester	Polyether
Process	Premix before production	One- short production
Machinery	Complicated, expensive, high pressure	Simple, less expensive, low-pressure
Properties	Poor elasticity, slightly tougher	Good elasticity, soft to touch
Uses	Carpet backing, lamination	Cushion, mattress, toys, upholsteris

Source: Makanjuola (1999b)

During the batch and continuous production processes, the main gases emitted were found to be carbon dioxide and methylene chloride. It had been found that several kilogrammes of blowing agents (mainly methylene chloride) are emitted in Nigerian foam industries (Makanjuola, 1999b). Also, in Federal Republic of Germany approximately 3.6 x 10^6 kg of blowing agents are emitted yearly by flexible foam production processes (Wolfgang and Peter, 1986). The composite reaction order in the production processes is zero with respect to methylene chloride emitted after a minimum concentration Co (Akeredolu et al, 2004)

Raw Materials in Polyurethane Foam Making

The essential raw materials used in manufactur4ing of flexible polyurethane foam can be categorized into the following (Makanjuola, 1999b).

i. Main Chemicals: these are Toluene di-isocyanate (TDI) and Polyol.
ii. Activators: They are Amine and Stannous Octoate (Tin II Octoate)
iii. Additives: These are also used in making polyurethane foam. They include colourants, fillers and flame retardants.
iv. Others: These chemicals include the primary blowing agent (water and auxiliary blowing agent (ABA).

However, additives and auxiliary blowing agents (ABA) are optional. It should be noted that all good formulations consist of main chemicals, activators, foam stabilizers and water. The cost of each chemical per kilogram differs. stannousoctoate. (Tin II Octoate) is the most expensive while water is obtained free of charge. The chemical composition of any foam depends on the density of the foam and its hardness. Therefore, foam of the same dimension but different densities will definitely vary in its chemical composition. (Makanjuola, 1999b).

Production of Polyurethane Foam

Foams that are found in Nigerian market can be produced using batch and continuous process. However, each process differs as a result of variation in the design of the machinery (Makanjuola, 1999b).

a. **Batch Process:** This process is traditionally referred to as ‘ Box Method’. It involves the use of simple mixing machines, mixing pot and the mould. The mould here is referred to as box. Each chemical is weighed into container according to formulation desired from the chemical drums. This process has been seriously discontinued as a result of emergence of continuous machine in line with technology development. Hence, most foam manufacturers are now opting for the continuous machine.
b. **Continuous Process:** This process is common in most big foam factories. Most box foamers are currently opting for this machine as a result of its higher efficiency, higher tonnage and higher reproducibility. It is characterized by huge storage tanks for polyol and toluene di-isocyanate (TDI).

In addition, all other chemicals have holding tanks serviced with metering pumps. Each stream is connected to an intensive mixing chamber. The resulting reaction mixture flows into troughs that lead into the mould. An air injector is located on the mixing chamber, which regulates the cell structure of the foam. The Table 2 below compares batch and continuous methods of polyurethane foam production.

Table 2: Merit and Demerit of Batch and Continuous Methods of Foam Production

Batch Method	Continuous Method
Capital outlay is minimal	Highly capital intensive
Process is slow and labour intensive	High volume production
Inefficient usage of chemicals	Highly efficient
Batch to batch quality reproductivity is poor. It depends on the skill of operation	Very reproducible
Operators are exposed to chemical fumes	Chemical Exposure is greatly reduced.
Low tonnage	High tonnage

Source: Makanjuola (1999a)

METHODOLOGY OF THE STUDY

The study was conducted in a polyurethane foam industry located in Southwestern Nigeria. The company, established in 1979 started its foam production by using a traditional batch method before finally shifting to using a continuous machine. Data were collected from secondary sources (published materials) and through questionnaire administered to senior company personnel in production, sales, marketing, accounts and general oversight.

The questionnaire contained questions on the company ownership, the production capacities of the company before and the adopting of continuous machine, non recurring expenditure for the two production methods (batch and continuous), recurring expenditure for the two methods of production. The non –recurring expenditure contained land and building requirement as well as the machinery and equipment requirement. The recurring expenditure includes the cost of raw materials, salaries and wages as well as other items which include cost of electric power, fuel, stationery and postage, telephone, transportation and packaging, advertisement, travelling expenses and other miscellaneous costs.

The results obtained were used in estimating and comparing capital requirements for the two foam production methods. Major accounting parameters such as "total cost of production", "profitability per month", production rate per month", operating profit per month", operating profit per annum" and "pay back time" were analysed and compared so as to see how these have changed considerably as a result of shifting to the continuous foam production method due to technological development.

Results and Discussion

Since 1979 when the company started producing polyurethane foam using the traditional batch method of foaming, it has been noticing a severe profit, maximum welfare for the staff as well as service to the community. However, the number of customers to the company has increased tremendously and therefore the company expansion programme became inevitable in 1996. This necessitated the company in opting for a continuous machine for production.

Then production capacity per month of the company rose tremendously while its need to satisfy more customers improved. Apart from these, the company now enjoys efficient material handling, adequate space allocation, reduced workers movement, increased flexibility for changing product designs and easy plant maintenance. Also, the immediate setting up of quality control lab became necessary so as lo control the quality of huge amount of raw materials and the finished products. This has helped the company a lot in the establishment of specifications, development of test procedure and sampling schedule and in the carrying out of the trouble-shooting during the plant operation. The results obtained from the questionnaires and the interviews were analytically compared in Tables 3, 4. 5 and 6.

The capital requirement for the establishment of the company is calculated from the non-recurring expenditure and the recurring expenditure per month. This is used in estimating the total cost of production, the operating profit per month and the operating profit per annum for batch and continuous production processes.

Table 5 below highlighted the company financial summary before and after opting for new technology development (using a continuous machine) for polyurethane foam production.

From the Tables 3, 4, 5 and 6" below one can clearly see that the operating profit per month increases by 600% as a result of shifting 10 usage of continuous machine by the company. Also, the operating profit per annum, the profit after lax (the net profit) all increased by the same percentage as a result of company embracing the latest technology for polyurethane foam production.

Table 3: Total Non-recurring Expenditure for the Batch and Continuous Methods

Non-Recurring Expenditure		
Items	**Batch Method (#)**	**Continuous machine**
Land and building requirement	3,450,000	5,250,000
Machinery and equipment requirement	900,000	30,000,000
Cost of electricity installation	112,500	750,000
Erection charge and commissioning	60,000	450,000
Office equipment and furniture	225,000	375,000
Provision of water facilities	60,000	90,000
Pre –operational expenses	22,500	37,500
Total non-recurring expenditure	**#4,830,000**	**#36,952,500**

Table 4: Production Rates for the Pre- and Pot Technology Development

Items	**Batch Method (#)**	**Continuous machine**
No. of foam blocks produced / month	180	1,138
Less for rejection	3	11
Production rate/month	180 blocks/month	1,238 blocks/month
Total sales (After less for rejection) month	7,923,000	49,513,500

Table 5: Total Recurring Expenditure for the Batch and Continuous Method

Recurring Expenditure		
Items	**Batch Method (#)**	**Continuous Machine**
Cost of raw materials/month	5,235,000	38,700,000
Salary of staff	360,000	675,000
Electric power	15,000	225,000
Fuel	15,000	30,000
Stationary &Postage	3,750	6,000
Transportation & Packaging	60,000	180,000
Advertisement	15,000	22,500
Travelling expenses	22,500	75,000
Provision of safety equipment	120,000	120,000
Medical facilities	45,000	22,500
Miscellaneous	15,000	30,000
Total recurring expenditure	**#5,928,000**	**#39,913,500**

Table 6: Profitability Estimation for Batch and Continuous Methods

Items	Batch Method (#)	Continuous Machine
Capital equipment		
Non recurring expenditure	4,830,000	36,952,500
Recurring expenditure	5,887,500	39,913,500
Total capital requirement	10,758,000	77,413,500
Total Recurring expenditure	5,887,500	39,913,500
10% Depreciation on machinery (10% of machinery and equipment)	247,500	262,500
Provision for bad debt i.e 1% on the Sale	82,500	495,000
Total cost of production	5,508,000	36,156,000
Total sales (after less for rejection) month	7,923,000	49,513,500
Less cost of production/ month	5,508,000	36,156,000
Operating profit per month	2,415,000	13,357,500
Operating profit/ annum (Operating profit/month x 12)	28,830,000	160,290,000
Less taxation (assuming 5% VAT and 5%) Tax	2,883,000	16,029,000
Operating profit /annum after tax	25,947,000	144,261,000
Pay back time	2 years	2 years, 8 months

Conclusion and Recommendation

The company performed very well from 1996 up to date after opting for a more sophisticated method of polyurethane foam production. During this period, the operating profit per month, the operating profit per annum, the profit after tax all increased by about 600%. The company is able to realize these because of high volume production, reduced wastage, high tonnage and reduced process and fugitive emissions attributed to the continuous machine.

Manufacturing companies should therefore as a matter of urgency evolve strategies and advices that will help them to reap the benefit of technology development.

Such strategies include process and product improvement programmes, new product development, effective maintenance management and spare part replacement policy.

Government on the other hand should encourage entrepreneur to opt for new technology by giving adequate loan and also encouraging banks to set up 10% of their profit as loan towards encouraging the business entrepreneur to opt for efficient and more productive processes. Also, government should ensure constant supply of electricity mid petroleum products that are vital to manufacturing.

Acknowledgement

The authors acknowledged the cooperation of the concerned staff of Yinka Oba Foam Nigeria Limited Ilesa. Also, we wish to appreciate the support of Managing Director of VITAFOAM NIG PLC Ikeja (Dr, Dele Makanjuola) for providing useful manuscripts.

REFERENCES

Adedeji.A, 2001. Lecture Delivered on Occupational Health Hazard at 3rd International Polyurethane Conference "U-Foam 2001, pp. 9-18,

Aja A. 2003. Lecture Delivered on Promoting Small/medium Scale Industries, Issues and Challenges, Nigerian Tribune, 21st of April 2003, pp. 25-26.

Akeredolu F.A, Jimoda, L.A and Sonibare J. A (2004) " Kinetics of Gas Production Reaction in Polyurethane Foam Production Process" Journal of Nigeria Society of Chemical Engineers. 20(1& 2): 60-68, Nigeria.

Berg. E. and Stafley. M. 1987 Divesting in Developing Countries, World Bank Discussion Papers No. 11

Business Times, 2000. The Stock Market, July, 23, 2000.

Duck.C.W.1-97K Plastics and Rubbers. Chemistry in Modern Industry Series, Butterworth& Company Publishers Ltd, pp. 76 - 85.

Dutse A.Y., NingiS.I. and Abubakar S. (2013).Technopreneurship and Enterprise Growth in Nigerian. An Exploration into the latent Role of Microfinance Banks. IQSR Journal of Business and Management (IOSRJRM) ISSN. 2228-487X Vol.12. Issue 2 Pp. 25-32.

Egbogah E.O (2012). The Role of Science and Technology in National Development: The Miracle of Malaysia and the future if Nigeria. Petroleum Technology Development Journal (ISSN 1595-9104) Vol.1

Lawal N.A. ,Lawal T.T. and Ojokuku R.M (2014) Technopreneurship and Entrepreneurship as Strategies for Technological and Economic Developments: Implication and Prospects. LAUTECH Journal of Engineering and Technology ISSN: 1597-0000 Vol.8(1) PP 23-29.

Makanjuola, D.1999a. Hand book of Flexible Foam Manufacture, TEMM Consulting Ltd, Ikeja.

Makanjuola, D. 1999b.Practical Techniques in Foam Making, TEMM Consulting Ltd., Ikeja.

Over cash, M.R. and Kaufman, C.M. 1993. Waste Minimization Strategy in Flexible Polyurethane Foams Manufacture, Air Waste Management Association Journal, Vol, 43, pp, 736-744, -

UBA (United Bank for Africa), Monthly Business and Economics: February - August.

Wolgang, G. and Peter, t. 1086. Recycling of Blowing Agenta (Chlorofluorocarbons) in the Production of Polyurethane Flexible Foam, Results from the Operation of a Pilot Installation, Proc,, 7th World Clean Air Congress (IUA PPA), Sydney, Australia, Vol.1, pp. 25-29.