Success Factors For Manufacturing And Service Industries In Zimbabwe

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***Abstract*—** The paper analyses how Industrial Engineering (IE) ideas may be applied to the Zimbabwean industry and the benefits that can be drawn from this discipline in order to improve the operations in Zimbabwean Industries.

***Keywords*—** Industrial Engineering, Zimbabwe, Productivity

I. Introduction

ALTHOUGH developing countries in the Sub-Saharian Africa have a higher Gross Domestic Product (GDP) than the rest of the word, Africa is still the poorest continent in the world. Its per capita GDP declined from 18% of the world average in 1960 to 11% of the world average in 2011. [4] This is well illustrated in the Figures 1 and 2:

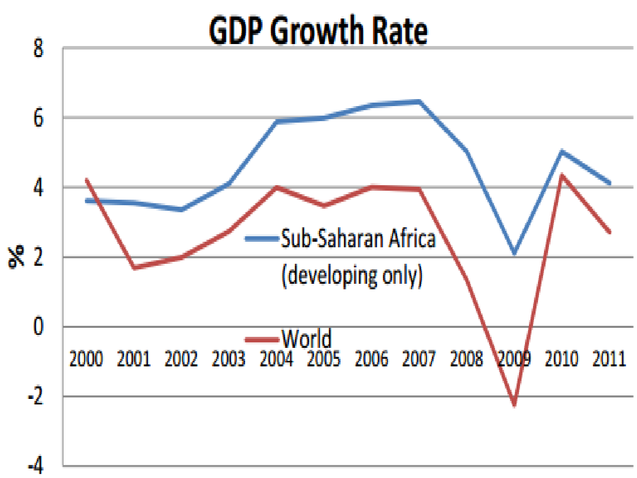

Figure 1: The GDP growth rate of Sub-Saharan Africa versus the rest of the world (Yifu Lin J, 2012)

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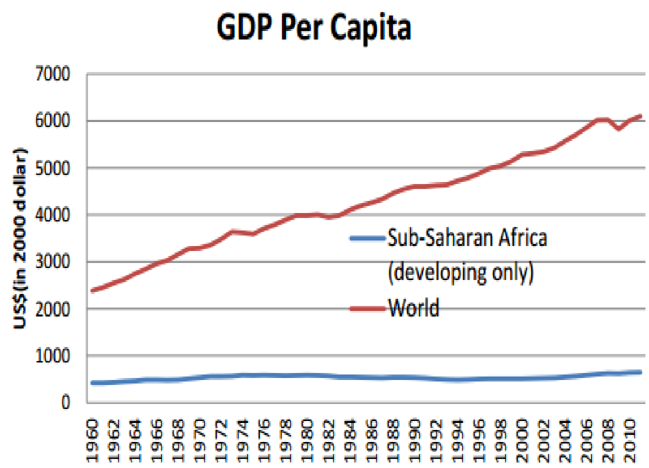

Figure 2: The GDP per capita of Sub-Saharan Africa versus the rest of the world (Yifu Lin J, 2012).

Salaheldin [9] points out that Egypt, like most less developed countries strives to diagnose and find solutions for the severe problems that are obstructing the growth and development of its industrial sectors. Problems like high scrap, losing market shares, high levels of inventory, poor quality in products and labor, long lead times and the existence of many sources of waste in production processes [9]. The Zimbabwe Manufacturing and Service industries are facing the same predicaments as most less developed countries and this is compounded by lagging behind in technology. Following a decade of economic decline and hyperinflation during the years 2007 and 2008 Zimbabwe's economy has started to grow. The emerging economic recovery has been supported by a significant improvement in economic policies. In February 2009, authorities established a multicurrency system. Under this system, transactions in hard foreign currencies are authorized, payments of taxes are mandatory in foreign exchange, and the exchange system largely was liberalized. [7].

Most companies in Zimbabwe, however, are still facing viability problems. All these have been the driver to this research paper.

II. Research Objective

The objective of this research is to hypothesize the benefits of industrial and manufacturing engineering in improving productivity in Zimbabwe Manufacturing and Service Industries.

III. RESEARCH METHOD

A wide range of published works, which contain the recent thoughts and debates of the globalization to developing nations are reviewed, analysed and critiqued. The authors take some case study examples and evidence from developing worlds, most notably in Zimbabwe.

IV. INDUSTRIAL ENGINEERING DEFINITION

Lo and Sculli [8] point out that one of the most widely accepted definitions of industrial engineering is the one used by the American Institute of Industrial Engineers: Industrial Engineering is concerned with the development, improvement, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, material and process. In lean manufacturing systems, Industrial engineers work to eliminate waste of time, money, materials, energy, and other resources. The industrial engineering profession has over the years evolved from methods engineering and work measurement, to a profession which now covers a wide range of skills which would be utilised by national and multinational organisations both large and small across all sectors of business. This wider range of skills include, plant layout, computer simulation, production planning, MRP systems, project management, motivation and psychology, industrial relations, engineering mathematics, quality management and resource planning. [3]

The world is turning “green”. People in all sectors of life are concerned with the environment, hence the next evolution of Industrial Engineering will include topics associated with the green economy. The skills required will include energy management, waste management, water and effluent treatment, sustainability and environmental management. [3] These skills will provide a wider scope for the employment of industrial engineers broadening the industry sectors in which they can operate. In the current testing economic climate the role of the industrial engineer is a catalyst for productivity improvement.

Industrial engineering has been around for 50 years and has stood the test of time [5]. It has primarily been concerned with:

1. The pursuit of organisational efficiency through methods improvement and resource-saving;
2. Organizational reform through business, market and technology development (Mohanty, 1998).

Industrial engineering is also known as Operations management, Production Engineering, Manufacturing Engineering or Manufacturing Systems engineering; a distinction that seems to depend on the viewpoint or motives of the user. Recruiters or Educational establishments use the names to differentiate themselves from others.

In healthcare Industrial Engineers are known as Clinical Engineers. The majority of clinical engineers serve as part of the healthcare team along with physicians, nurses, technologists, and other hospital staff. The clinical engineer's role is to ensure that other team members have adequate and effective technology for the time delivery of quality healthcare. In essence, clinical engineers must act as the "stewards" of healthcare technology. As effective stewards, clinical engineers need to understand the practitioners' intent, they need to possess knowledge with respect to both existing and developing healthcare technology, and they must also understand the various implications of applying the technology. Only when forearmed in this manner can clinical engineers hope to serve as successful stewards and help insure healthcare technology is applied for the greatest benefit. The implications of technology adoption and integration between diagnostic, information processing, and therapeutic systems are discussed. [6].

Applications of Industrial Engineering principles vary widely. Jimmerson C, [1] alludes to this fact: The Toyota Production System (TPS), based on industrial engineering principles and operational innovations, is used to achieve waste reduction and efficiency while increasing product quality. Several key tools and principles, adapted to health care, have proved effective in improving hospital operations.

Masin and Vytlacil [2] stated that very few managers in the Czech Republic, at the turn of the twentieth century, knew about the field of ``industrial engineering"(IE) an approach with a strong tradition of, and a significant effect on productivity measurement and improvement. They go on to say that the realisation that ``catch up" must be strong and quick is forcing the adoption of a number of the tools and techniques, and especially the basic approaches of IE. Companies are finding that they need to utilize the most-up-to-date industrial engineering methods; and information on the use of such methods is more readily available. Departments of industrial engineering have been created in two universities in Zimbabwe which points to the realization by the government and industry that IE methods are the answer to improving productivity.

Whereas most engineering disciplines apply skills to very specific areas, industrial engineering is applied in virtually every industry. Examples of where industrial engineering might be used include shortening lines (or queues) at a theme park, streamlining an operating room, distributing products worldwide, and manufacturing cheaper and more reliable automobiles. The name "industrial engineer" can be misleading. While the term originally applied to manufacturing, it has grown to encompass services and other industries as well. Similar fields include operations research, systems engineering, ergonomics and quality engineering. The unicist approach to engineering considers industry as a complex system.

V. DISCUSSIONS

There are a number of things that Industrial Engineers do in their work to make processes more efficient, to make products more manufacturable and consistent in their quality, and to increase productivity. The expertise required by Industrial Engineers allows them to:

- Investigate problems relating to component quality or difficulties in meeting design and method constraints
- Investigate problems with the performance of processes or machines and
- Implement design changes at the appropriate times.

To achieve these, the following elements are applied. People with limited education qualifications or limited experience may specialize in only a few.

A. Specifically per Product (short term)

1. Analysis of the complete product design to determine the way the whole process should be split into steps, or operations, and whether to produce sub-assemblies at certain points in the whole process. This requires knowledge of the facilities available in-house or at sub-contractors
2. Specification of the method to be used to manufacture or assemble the product(s) at each operation. This includes the machines, tooling, jigs and fixtures and safety equipment, which may have to be designed and built. Notice may need to be taken of any quality procedures and constraints, such as ISO9000. This requires knowledge of Health and Safety responsibilities and Quality policies. This may also involve the creation of programs for any automated machinery.
3. Measurement or calculation of the time required to perform the specified method, taking account of the skills of the operator. This is used to cost the operation performed, to allow balancing of assembly or machining flow lines or the assessment of the manufacturing capacity required. This technique is known as Work Study. These times are also used in Value Analysis.
4. Specification of the storage, handling and transportation methods and equipment required for components and finished product, and at any intermediate stages throughout the whole process. This should eliminate the possibility for damage and minimize the space required.

B. Specifically per Process (medium term)

1. Determine the maintenance plan for that process.
2. Assess the range of Products passing through the process, then investigate the opportunities for process improvement through a reconfiguration of the existing facilities or through the purchase of more efficient equipment. This may also include the out-sourcing of that process. This requires knowledge of design techniques and of investment analysis
3. Review the individual Products passing through the Process to identify improvements that can be made by redesign of the Product, to reduce (or eliminate) the cost that process adds, or to standardize the components, tooling or methods used.

C. Generically (long term)

1. Analyse the flow of Products through the facilities of the factory to assess the overall efficiency, and whether the most important Products have priority for the most efficient process or machine. This means maximizing throughput for the most profitable products. This requires knowledge of statistical analysis and queuing theory, and of facilities positional layout.
2. Training of new workers in the techniques required to operate the machines or assembly processes.
3. Project planning to achieve timely introduction of new products and processes or changes to them.
4. Generally, a good understanding of the structure and operation of the wider elements of the Company, such as sales, purchasing, planning, design and finance; including good communication skills. Modern practice also requires good skills in participation in multi-disciplinary teams.

D. Value engineering

Value engineering is based on the proposition that in any complex product, 80% of the customers need 20% of the features. By focusing on product development, one can produce a superior product at a lower cost for the major part of a market. When a customer needs more features, sell them as options. This approach is valuable in complex electromechanical products such as computer printers, in which the engineering is a major product cost.

To reduce a project's engineering and design costs, it is frequently factored into subassemblies that are designed and developed once and reused in many slightly different products. For example, a typical tape-player has a precision injection-molded tape-deck produced, assembled and tested by a small factory, and sold to numerous larger companies as a subassembly. The tooling and design expense for the tape deck is shared over many products that can look quite different. All that the other products need are the necessary mounting holes and electrical interface.

E. Quality assurance/quality control

1. Quality control is a set of measures taken to ensure that defective products or services are not produced, and that the design meets performance requirements. Quality Assurance covers all activities from design, development, production, installation, servicing and documentation. This field introduced the rules “fit for purpose” and “do it right the first time”.
2. It is a truism that "quality is free." Very often, it costs no more to produce a product that always works, every time it comes off the assembly line. While this requires a conscious effort during engineering, it can considerably reduce the cost of waste and rework.
3. Commercial quality efforts have two foci. First, to reduce the mechanical precision needed to obtain good performance. The second is to control all manufacturing operations to ensure that every part and assembly are within a specified tolerance.
4. Statistical process control in manufacturing usually proceeds by randomly sampling and testing a fraction of the output. Testing every output is generally avoided due to time or cost constraints, or because it may destroy the object being tested (such as lighting matches). The variances of critical tolerances are continuously tracked, and manufacturing processes are corrected before bad parts can be produced.
5. A valuable process to perform on a whole consumer product is called the "shake and bake." Every so often, a whole product is mounted on a shake table in an environmental oven, and operated under increasing vibration, temperatures and humidity until it fails. This finds many unanticipated weaknesses in a product. Another related technique is to operate samples of products until they fail. Generally the data is used to drive engineering and manufacturing process improvements. Often quite simple changes can dramatically improve product service, such as changing to mold-resistant paint, or adding lock-washed placement to the training for new assembly personnel.
6. Many organizations use statistical process control to bring the organization to Six Sigma levels of quality. In a six sigma organization, every item that creates customer value or dissatisfaction is controlled to assure that the total numbers of failures are beyond the sixth sigma of likelihood in a normal distribution of customers setting a standard for failure of fewer than four parts in one million. Items controlled often include clerical tasks such as order-entry, as well as conventional manufacturing processes

F. Produceability

1. Quite frequently, manufactured products have unnecessary precision, production operations or parts. Simple redesign can eliminate these, lowering costs and increasing manufacturability, reliability and profits.
2. For example, Russian liquid-fuel rocket motors are intentionally designed to permit ugly (though leak-free) welding, to eliminate grinding and finishing operations that do not help the motor function better.
3. Some Japanese disc brakes have parts toleranced to three millimeters, an easy-to-meet precision. When combined with crude statistical process controls, this assures that less than one in a million parts will fail to fit.
4. Many vehicle manufacturers have active programs to reduce the numbers and types of fasteners in their product, to reduce inventory, tooling and assembly costs.
5. Another produceability technique is near net shape forming. Often a premium forming process can eliminate hundreds of low-precision machining or drilling steps. Precision transfer stamping can quickly produce hundreds of high quality parts from generic rolls of steel and aluminum. Die casting is used to produce metal parts from aluminum or sturdy tin alloys (they are often about as strong as mild steels). Plastic injection molding is a powerful technique, especially if the special properties of the part are supplemented with inserts of brass or steel.
6. faster, digital signal processing software is beginning to replace many analog electronic circuits for audio and sometimes radio frequency processing
7. On some printed circuit boards (itself a producibility technique), the conductors are intentionally sized to act as delay lines, resistors and inductors to reduce the parts count. An important recent innovation was to eliminate the leads of "surface mounted" components. At one stroke, this eliminated the need to drill most holes in a printed circuit board, as well as clip off the leads after soldering.
8. In Japan, it is a standard process to design printed circuit boards of inexpensive phenolic resin and paper, and reduce the number of copper layers to one or two to lower costs without harming specifications.
9. It is becoming increasingly common to consider producibility in the initial stages of product design, a process referred to as design for manufacturability. It is much cheaper to consider these changes during the initial stages of design rather than redesign products after their initial design is complete.

G. Motion economy

1. Industrial engineers study how workers perform their jobs, such as how workers or operators pick up electronic components to be placed in a circuit board or in which order the components are placed on the board. The goal is to reduce the time it takes to perform a certain job and redistribute work so as to require fewer workers for a given task.
2. Industrial engineers frequently conduct time studies or work sampling to understand the typical role of a

worker. Systems such as *MOST* have also been developed to understand the work content of a job.

3. Frederick Winslow Taylor and Frank and Lillian Gilbreth did much of the pioneering work in motion economy. Taylor's work sought to study and understand what caused workers in a coal mine to become fatigued, as well as ways to obtain greater productivity from the workers without additional man hours. The Gilbreths devised a system to categorize all movements into subgroups known as therbligs (Gilbreths spelled backwards). Examples of therbligs include hold, position, and search. Their contributions to industrial engineering and motion economy are documented in the children's book Cheaper by the Dozen.

VI. Recommendations

A. Industrial Engineering Tools

In industrial engineering, the research tools and techniques aim at improving the productivity of organizations by optimum utilization of organization's resources that are men, materials and methods. The various tools and techniques of industrial engineering which manufacturing and service industries in Zimbabwe should use are as follows:

1. Method study: to establish a standard method of performing a job or an operation or thorough analysis of the jobs and to establish the layout of production facilities to have uniform flow of material without tracking
2. Time study (work measurement): this is a technique used to establish a standard for a job or for an operation.
3. Financial and non-financial incentives: these help to evolve a rational compensation for the efforts of the workers
4. Production, planning and control: this includes the planning for the resources (men, materials and machines), proper scheduling and controlling production activities to ensure the right quantity, quality of product at predetermined time and pre-established.
5. Inventory control: to find the economic lot size and reorder level for the items should be made available to the production at the right time and quantity to avoid stock out situation and with minimum capital lockup
6. Job evaluation: this is used to determine the relative worth of the organization to aid in matching jobs and personnel and to arrive at sound policy
7. Materials handling analysis: to scientifically analyse the movement of materials through various departments to eliminate unnecessary movement and to enhance the efficiency of material handling
8. Ergonomics (human engineering): it is concerned with the study of relationship between man and his working conditions to minimize mental and physical stress. It is concerned with man-machine system
9. System analysis: the study of various sub-systems and elements that make a system, their interdependencies (connections) in order to design, modify and improve them to achieve greater efficiency and effectiveness

B. Operations research techniques

These techniques aid to arrive at the optimal solutions to the problems based on the set objective and constraints imposed on the problems. The techniques of operations research that are frequently used are:

1. Linear programming problems
2. Simulation models
3. Queuing models
4. Network analysis (CPM and PERT)
5. Assignment, sequencing and transportation models
6. Dynamic and integer programming
7. Games theory

VII. Conclusion

The discussion is not about whether to adopt or not to but to bring industrial engineering as a must to companies in Zimbabwe. The industrial engineering personnel can act as catalysts in this endeavor. But the guiding spirit should come from management. Training in Industrial Engineering techniques should be the motivator for all manufacturing and service companies in order to improve on their performance. Training should also be instituted with the same zeal given to profiteering.

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