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

7.6 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.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.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.Many vehicle manufacturers have active programs to reduce the numbers and types of fasteners in their product, to reduce inventory, tooling and assembly costs.
2. 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.
3. Faster, digital signal processing software is beginning to replace many analog electronic circuits for audio and sometimes radio frequency processing
4. 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.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.
5. It is becoming increasingly common to consider produceability 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.
6. Produceability involves consideration of the environmental harm. Heavy fines are being implemented in developed countries as a measure of insisting on “greener” manufacturing. This technique is encouraged to be implemented even on already functional systems.

7.7 Motion economy

1. Industrial engineering studies 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 engineering frequently conducts 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.

8 Recommendations

8.1 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:

i. 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
ii. Time study (work measurement): this is a technique used to establish a standard for a job or for an operation.
iii. Financial and non-financial incentives: these help to evolve a rational compensation for the efforts of the workers
iv. 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.
v. 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
vi. 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
vii. 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
viii. 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
ix. 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

8.2 Six goals of green engineering

The following should be the target of all the industries in Zimbabwe:

i. Selection of low environmental impact materials
ii. Avoiding toxic or hazardous materials.
iii. Choosing cleaner production processes.
iv. Maximising energy and water efficiencies.
v. Designing for waste minimization.
vi. Designing for recyclability and reuse of material.

8.3 Operations research techniques

These techniques assist in arriving at the optimum solutions to the difficulties based on the set objective and constraints imposed on the challenges. The techniques of operations research that are frequently used are:

i. Linear programming problems
ii. Simulation models
iii. Queuing models
iv. Network analysis (CPM and PERT)
v. Assignment, sequencing and transportation models
vi. Dynamic and integer programming
vii. Games theory

9 Conclusion

The discussion is not on whether to implement or not to but to bring industrial engineering and environmental sustenance 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 top management. Training in Industrial Engineering and Environmental Sustenance 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 passion given to making of profits.

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Biography

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