ABSTRACT
The inability of many manufacturing companies to remain viable and also compete effectively in today’s world class manufacturing has been blamed extensively on their difficulty to identify, reduce, and possibly eliminate all wastes that are inherent in their manufacturing processes. This paper introduced the concept of waste (otherwise known as muda in Japan) in Lean Production System, and also gave a detailed explanation of the entire 7+1 wastes that bedevils manufacturing processes. The various approaches, tools and techniques of tackling muda were discussed in detail, although it was noted that companies will not achieve the desired results if the tools are not properly utilized; the paper went a step further to discuss their specific applications and benefits which will assist in starting improvement processes, increase the overall awareness of quality, and also enhance the change of attitude of employees. Finally the paper concluded that the effective tackling of all wastes in manufacturing processes will not only enable companies to remain competitive, but will also lead to increased throughput, as waste identification and subsequent elimination is one of the most effective ways of increasing the profitability and viability of any business.

KEYWORDS: Muda, Wastes, Manufacturing Processes, Tackling, Elimination.

I INTRODUCTION
In Lean Production System, waste (which is referred to as muda in Japan) is described as anything that destroys resources and does not add any value to the customer’s requirements. This is because manufacturing waste is the application of resources like raw materials, labour, equipment, or machines over and above what is needed to produce the product or service defined by the customer. Consequently, any activities, or processes which the customer is not willing to pay for is a waste inherent in production processes and must be identified and eliminated.

Today’s production concept is geared towards turning manufacturing which used to be full of wastes into a properly organized, efficient, and more profitable venture. Waste identification and subsequent elimination is one of the most effective ways to increase the profitability and viability of any business. Lean Production System aims at the optimization of all manufacturing processes and waste elimination, thereby cutting production cost and ensuring timely delivery of the customer’s requirements.

As all manufacturing processes either add waste or value to the production of a good or service, to identify and subsequent eliminate waste, it is pertinent to have a complete understanding of waste and where it exists. Although products and services significantly differ between companies, the distinctive wastes inherent in manufacturing processes are quite similar. For each of the wastes, there is a proven strategy to reduce or possibly eliminate its effect on a company, in order to improve the overall quality and performance.

With this manufacturing concept, companies enjoy the benefit of continuous improvement. So, rather than making hasty and lopsided changes that are disruptive to the workplace, it ensures little and sustainable changes that the employers who add value to the processes, equipment, and materials will imbibe. This efficient and simple system is very successful across all types of industries, as a process that is devoid of waste is much more sustainable.

II THE INHERENT WASTES IN MANUFACTURING PROCESSES

Lean Production System (LPS) which is the World’s best practice in manufacturing is not aimed at working faster and better, but to identify and eliminate all forms of wastes. Recognizing all non-value activities in manufacturing processes as wastes leads to the identification of their root causes for immediate reduction and possible elimination. Treville and Antonakis (2006) defined Lean Production system as “an integrated manufacturing approach that is intended to maximize the capacity utilization and minimize the buffer inventories of a given operation through minimizing system variability (related to arrival rates, processing times, and process conformance to specifications).” It is also a manufacturing approach and technique that is applied to achieve continuous improvement through the identification and elimination of wastes.

According to Ihuze and Okpala (2012), Apart from wastes identification and elimination, LPS enables organizations to be more profitable through the application of less resources to manufacture more quality products at a faster rate, thereby leading to competitive advantage and customer satisfaction. It has been observed that the two biggest wastes inherent in manufacturing are the queuing of materials (Waiting) and over-production. In her study Page (2004), explained that “eliminating over-production reduces work in progress, and in doing so makes the system more responsive, complacency about rejects is reduced and valuable resources are not wasted on product that has no immediate sales value.” She also stated that unnecessary queue of inventories results when efforts are made to maximize the overall efficiency of individual operating parts, thereby leading to increase in lead time and over spacing of operations that ought to be very close.

As shown in figure 1, and also observed by Ihuze and Okpala (2012), the seven wastes that LPS aims to eliminate which bedevils manufacturing companies and reduces their profitability and throughput are Transportation, Inventory, Movement, Waiting, Over-production, Over-processing, and Defects. However, in recent years another waste known as Under-utilization of people has been added to the original seven wastes, hence the 7 + 1 wastes.
Over-Production
Often considered as the worst of all the seven wastes, over-production is simply the production of unordered materials, or manufacturing a product before it is actually needed by the customer. Over-production is very expensive to the manufacturer as it forbids the even movement of raw material inventory, thereby compromising productivity and efficiency, and also resulting to complications in defect detection, increase lead times, as well as high cost of storage.
Over-production is at variance with the basic principle of waste-elimination, as the excess products tie money down and accrues the cost of maintenance and storage, as well as the following risks: Inferno, obsolescence, and theft. According to Page (2004), “eliminating over-production reduces work in progress, and in doing so makes the system more responsive, complacency about rejects is reduced and valuable resources are not wasted on product that has no immediate sales value.”

WAITING
Materials waiting around in companies either as raw materials, work in progress, or finished goods add zero value to the product and is a major cause of waste. The waste of Waiting is the idle time that occurs when co-dependent events are not synchronized, this is because the process of manufacturing is reliant on the procedures that occur downstream and upstream. When the equipment, machines, operators, materials, or information delay the process of production, it results to time wastage and the increase of production cost and reduced profit.
According to Lantech (2013), the waste of waiting in manufacturing processes are “bottlenecks in time, usually due to broken machinery, lack of trained staff, shortages of materials, inefficient planning, or as a result of the six other mudas.” They concluded that it is an unproductive time that is paid for, and that at their worst, they can lead to production slow down, delay in shipments, and even missing of deadlines. A sizeable part of a product’s lead time becomes tied up while waiting for the next process; this is mainly because the flow of material is slow, production sequences are very long, and gaps between work points are too large. Ensuring that processes are linked together and that the operation in front draws directly from the one at the rear will reduce the waste of waiting significantly. As the waste of waiting interrupts flow, it’s elimination will ensure the smoothening of the entire production processes.

TRANSPORTATION
The waste of transportation is defined as the needless movement of materials, work-in-progress, finished goods, items, and information from one place to another without the addition of any value to the product. The avoidable transportation which wastes money, time, and resources is characterized by unnecessary motion which leads to deterioration and possible loss of products. This waste costs establishment so much as personnel, equipment, and machines are required to carry out the costly movements which is not directly associated with value adding operations.
The major causes of excessive transportation on shop floors include: maintaining of different warehouses, bulky batch sizes, difficult material handling processes, over-production, and improper layouts. However, it could be reduced by adopting cellular manufacturing which should ensure that operations are maintained close to each other, thereby leading to uninterrupted material flows that are devoid of delays.

EXCESS INVENTORY
Inventory is the quantity of components needed to manufacture a product, work-in-progress, consumables, or finished goods kept in the warehouse. Any supply of inventory in excess of process or demand requirements is known as excess
inventory, it is another form of waste as it ties money that could have been properly utilized down. The keeping of excessive inventory is quite expensive to any company as apart from its direct cost, there are also the costs of transportation, storage in the warehouse, as well as insurance. Also the risks associated with excess inventory include: pilfering, obsolescence, and infirmo. Excess inventory tends to conceal problems on the shop floor, which must be recognized and resolved in order to improve the performance of the operations. It also expands lead times, postpones problem identifications, hampers effective communication, and also litters the shop floor spaces. To effectively reduce the inventory level and its attendant costs conscious efforts must be geared towards attaining an unbroken flow between the operations.

DEFECTS
Defects in manufactured products are always difficult to identify before they are purchased by the customers, even though they are the most noticeable of all the wastes. Mistakes and errors that lead to defects is very expensive to manufacturers as all defective products require replacement or rework with its attendant cost, thereby leading to the wastage of time and resources, as well as loss of customers. Unwholesome raw materials, bad or inferior manufacturing operations because of faulty equipment and/or human error are the major causes of defects. Defective products leads to customer’s dissatisfaction and less patronage, the company also waste a lot of time and money trying to rework the product, and also fix the problem. Other costs associated with defects include: inspection, rescheduling, recall of defective products, capacity loss, and market share. Through management approval, and employees involvement, the introduction of Continuous Improvement (PokaYoke) and Autonomation helps to identify and reduce the causes and production of defective products.

MOVEMENT/MOTION
The waste of Movement or Motion is the unnecessary movement of personnel and operators in the shop floor without the addition of any value on products and services, thereby leading to waste of time and efforts. These avoidable movements occur because of badly organized layout, low standard processes, poorly trained workforce, and bad process design. Motion is associated with ergonomics as it is observed in all cases of running, walking, jumping, bending, lifting, stretching, and kneeling. All these motions are wastages as they don’t just cost money but also stress and wear out to the equipment, machines and personnel. They are often regarded as safety and health matters which constitute problems for companies, efforts should therefore be made to ensure that jobs that have excess movements should be identified and redesigned for improvement.

OVER-PROCESSING
Over-processing is very wasteful as it is the additional values added to an already finished product which the customer is not willing to pay more money for. It is also the manufacturing of higher quality products or components of higher quality than is needed as a result of non-standardization of best procedures, ineffective processes, ambiguous quality acceptance standards, faulty equipment, poor communication, unnecessary manufacturing processes, the use of outdated techniques, and overzealous workers. Some over-processing activities include: painting of hidden areas in vehicles, installation of excess bulbs in car headlamps, polishing beyond the required level, and needless tight tolerances. According to Emsstrategies (2003), over-processing is often referred to as “using a sledgehammer to crack a nut, many organizations use expensive high precision equipment where simpler tools would be sufficient.” They observed that this often results in poor plant layout because preceding or subsequent operations are located far apart. Efforts to reduce over-processing will include: the creation of manufacturing cells, adequate staff sensitization, as well as the combination of production steps.

UNDER-UTILIZATION OF EMPLOYEES
The inability of establishments to make efficient use of their employees has recently been added as the eighth form of waste in manufacturing. This is because a company’s staff is its greatest asset who if properly harnessed will help to identify and eliminate all the other forms of wastes. According to Leantools (2012), many manufacturers still tend to operate within a command and control environment and take little real notice of what their employees really think and what they can contribute. By capitalizing on their employees’ ingenuity and innovations, establishments can greatly improve their overall performance, thereby leading to competitive advantage and customer satisfaction.

III THE TOOLS AND TECHNIQUES FOR TACKLING MUDA
The application of OMS tools and techniques assists in starting improvement processes, increasing the overall awareness of quality and also enhances the change of attitude of employees. Dale (2003) explained that tools and techniques of LPS are used to “aid quality planning, listen to the ‘voices’ of the customer, capture data, control processes, make improvements, solve problems and improve people.” However, the various tools and techniques will not achieve the desired results if they are not properly utilized; this is because LPS is not just the application of a bunch of tools but rather a completely different approach of manufacturing. This was pointed out by Lang and Hugge (1995) as they argued that “although a lot of techniques and tools have been associated with the concept of optimum design and manufacturing, they prove to be futile unless they are integrated with thorough understanding of the manufacturing processes, redefinition of the currently adopted processes and multidiscipline teams assigned to implement changes.”

As shown in figure 2, some of the tools and techniques of OMS include: Cellular Manufacturing, Just-In-Time, Total Productive Maintenance, Value Stream Mapping, Poka Yoke (Error Proofing), Five-S practice, Single Minute Exchange of Dies, Takt Time Analysis, Kaizen (Continuous Improvement), and Visual Management. The seven deadly wastes, thier brief descriptions, and the tools and techniques used in tackling them are shown in Table 1.
Figure 2: LPS Tools and Techniques' house.  
(Source: Swmas, http://www.swmas.co.uk/Lean_Tools/Lean_menu.php)

<table>
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<tr>
<th>Seven Wastes</th>
<th>Deadly Description</th>
<th>Solution (Lean Tools)</th>
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| Overproduction | Making something before it is truly needed. This is a particularly serious form of waste because it leads to excess inventory that is often used to mask other underlying problems and inefficiencies. | - Pace production so the rate of manufacturing matches the rate of customer demand (Takt Time).  
- Use a pull system to control how much is manufactured (Kanban).  
- Reduce setup times so that smaller batches can be economically manufactured (SMED). |
| Waiting | Time when work-in-process is waiting for the next step in production (no value is being added). It can be truly illuminating to look at the time from order to shipment and ask how much of that time is actually spent on true value-added manufacturing. | - Design processes so that the flow is continuous and there are minimal or no buffers between steps in production (Continuous Flow).  
- Use standardized work instructions to ensure that a consistent method and consistent times are used for each step of production (Standardized Work). |
| Transport | Unnecessary movement of raw materials, work-in-process or finished goods. | - Design a linear, sequential flow from raw materials to finished goods (Value Stream Mapping).  
- Make sure work-in-process is not placed into inventory (Continuous Flow).  
- Avoid continual changing of job priorities (Theory of Constraints). |
| Motion | Unnecessary movement of people, movement that does not add value. | - Ensure that work areas are logically organized (5S).  
- Consider alternate arrangements of equipment that reduce motion (Value Stream Mapping). |
| Overprocessing | More processing than is needed to produce what the customer requires. This is often one of the more difficult wastes to detect and eliminate. | - Compare customer requirements to manufacturing specifications (Kaizen).  
- Look for potential simplifications to the manufacturing process (Kaizen). |
| Inventory | Product (raw materials, work-in-process, or finished goods) quantities that go beyond supporting the immediate need. | - Bring raw materials in only as they are needed (Just-In-Time).  
- Reduce or eliminate buffers between steps in production (Continuous Flow).  
- Refer to Overproduction countermeasures (Takt Time, Kanban, and SMED). |
| Defects | Production that is scrap or requires rework. | - Design processes so they are less likely to produce defects (Poka-Yoke).  
- Design processes to detect abnormalities so they can be immediately corrected (Jidoka).  
- Look for the single most frequent defect and determine why it occurs (Root Cause Analysis).  
- Create work instructions that provide a consistent method of manufacturing the part (Standardized Work). |

Table 1: Tools and Techniques for Tackling Muda.  
(Source: Alzatex, http://lean-timer.com/seven-deadly-wastes/)
Cellular Manufacturing
Cellular manufacturing can be defined as a tool and technique of LPS where machines and equipment are properly arranged in order to enhance the steady and uninterrupted movement of materials and tools through the process of production without stoppages and time wastage. Levinson and Rerick (2002) observed that it is “only by relating each machine with the others in such a way that production will follow in straight lines without confusion, can the highest economy operation be attained.”
The main benefit of Cellular Manufacturing is that it assists organizations to reduce the overhead cost, as an individual worker can monitor and manage series of machines and equipment in a production channel. Also it encourages flexible manufacturing as well as reduces the wastage of shop floor space. Its proper application enhances flow, and also helps in no small measure in tackling the wastes of transportation, movement, and waiting.

Just in Time (JIT)
Just-In-Time production which involves the identification and tackling of problems, as well as production cost elimination is one of the most widely used tools of LPS. It enables manufacturers to manufacture the exact amount of products their customers need and at the time they are required. The main strength of JIT tool is its ability to better and evenly spread out manufacturing over a required period of time, as well as the provision of products and services when they are required. It also enables manufacturers to maintain the lowest possible inventory by being in constant touch with their suppliers, thereby leading to constant waste reduction. Just in time (JIT) is used in tackling the wastes of Over-production and Excess inventory.

Total Productive Maintenance (TPM)
Total Productive Maintenance which emphasizes on the importance of teamwork is focused on enhancing the expertise of machine operators through education and trainings to enable them to take adequate care and maintenance of their company’s machineries and equipment for better operating efficiency. Nakajima (1988), concluded that its double aim is to completely eliminate defective products and machine breakdowns. He maintained that achieving this leads to the reduction of costs and inventory, improvement of equipment operation, as well as a considerable increase in labour productivity. The application of TPM has proved to be invaluable in the reduction and elimination of defective products (defects), and excess inventory.

Value Stream Mapping (VSM)
Value stream mapping is an effective LPS tool that involves the use of paper and pencil, and assists in the understanding and monitoring information and material flow in a manufacturing plant as materials flow across the value stream from raw material to shipping. Its implementation assists an organization to improve the quality of its products, reduce the cost of manufacturing and lead time.
Womack (2006), explained that identifying the family (set of components which move along the same activities and machines in a manufacturing company) of a product is the first approach of mapping process. He maintained that mapping is made quite easy and its benefits greatly enhanced when decisions were taken at the beginning to appropriately classify products according to families. The application of VSM is very essential in the fight against the wastes of Movement/Motion and Transport.

Poka Yoke (Error Proofing)
Poka Yoke is employed in the elimination of the manufacturing of defective products by ensuring the stoppage of production processes whenever an error is detected, thereby leading to reduction of production costs. In most cases the concept adopts the use of cheap approaches that assists in the detection and prevention of defects without necessarily requiring the absolute concentration of the workers, by either eliminating the mistake or signaling to the worker about the mistake that is about to be made. With the application of Poka Yoke employees are able to self-check the work in progress during manufacturing thereby ensuring that a defective product does not pass through the production line.

Five-S Practice
Five-S Practice is aimed at increasing productivity by sanitizing as well as ensuring a neat and well arranged shop floor; it also adopts the use of visual signs to ensure greater benefits. Skinner (2003), explained that the application of Five-S practice leads to the reduction of wastes of waiting, unnecessary movement, excess inventory, as well as wastes in other manufacturing processes.

Single Minute Exchange of Dies (SMED)
With quick changeover, SMED contributes immensely to increase in flexibility, production capacity and the maintenance of very low inventory, as one-piece flow and streamlining operations can easily be achieved. Also the application of SMED enables manufacturing companies to be more competitive by achieving the following: a decrease in lot size production, setup time reduction, decrease in planning and scheduling overhead, waste elimination, and more efficient utilization of material resources, thereby leading to the production of high quality products that meets the customer’s requirements. Its application produces great results in tackling the wastes of Waiting, Excess inventory and Over-production.

Takt Time Analysis
Takt time which is calculated as the (available time) divided by the (demand required) is applied in LPS to ensure that the customer’s requirement are met through timely provision of products, thereby ensuring that excess manufacturing of products which translates to waste is avoided. Zylstra (2011) noted that during production when there is a less demand for products, the takt time is increased through re-allocating the workers and reducing the inventory accordingly, while the takt time is determined again and subsequently reduced when the customer’s demand increased thereby resulting in increase in the number of products, in order to ensure customer satisfaction. TTA is applied in tackling the wastes of Over-production and Excess inventory.

Kaizen (Continuous Improvement)
Laraia, Moody and Hall (1999), explained that Kaizen is the best approach of identifying and utilizing adequately the skills that a company and its
workers already have for positive results that ensures the achievement of fast, obvious and sustainable success. Constant monitoring and evaluation are also used to ensure the sustenance of the adopted improvements. Companies have come to realize that Kaizen is a very important management technique because of its more efficient and faster ways of achieving success. In order to remain competitive and focused in a world of globalization and diverse technologies, the adoption of Kaizen techniques by organizations is one of the most efficient ways of beginning a continuous improvement approach that will lead to positive achievements and production of high quality and innovative products. For Kaizen to be successfully implemented in a company, it requires full commitment and contribution of an entire company’s workforce. Kaizen is widely applied in the tackling of Over-processing waste.

**Visual Management**

Commenting on the crucial characteristic of visual management Nicholas (1998), observed that “information about levels of waste, quality, productivity, and service is collected and posted along with goals so that workers can readily see trends and gaps between goals and practice.” Visual management was invented as a means of communicating effectively with the employees in order to improve manufacturing processes. It leads to increase in the rate of production and manufacturing flexibility. Visual Management finds its application in curbing the wastes of Motion, Defects, as well as Transportation.

**Single Piece Flow**

Often regarded as one of the best approaches of manufacturing products in a company, Single Piece Flow is a one component at a time continuous movement of raw materials and work in progress in a shop floor. Single-piece flow enhances the rate of production, profitability as well as elimination of wastes. However, its limitation lies in its inability to be used in all processes of production especially in manufacturing setups that produces different types of products. It is applied in tackling the waste of Over-Production, and Defects.

**IV. CONCLUSION**

Today’s production concept is geared towards turning manufacturing which used to be full of wastes into a properly organized, efficient, and more profitable venture. Waste identification and subsequent elimination is one of the most effective ways to increase the profitability and viability of any business. As all manufacturing processes either add waste or value to the production of a good or service, to identify and subsequent eliminate waste, it is pertinent to have a complete understanding of waste and where it exists. Although products and services significantly differ between companies, the distinctive wastes inherent in manufacturing processes are quite similar. For each of the wastes, there is a proven strategy to reduce or possibly eliminate its effect on a company, in order to improve the overall quality and performance. The effective identification, tackling and subsequent elimination of all wastes in manufacturing processes will not only enable companies to remain competitive, but will also lead to increased throughput, rate of productivity, flexibility, inventory turnover, customer relationship, profitability, and quality of products.

**REFERENCES**