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MANUFACTURING COST ANALYSIS OF AUTOMATED PAP MAKING MACHINE DESIGN INNOVATION

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ABSTRACT

Manufacturing Cost Analysis improves the client's understanding of key cost drivers and process differentiators associated with a specific product line and assesses how they vary by technology, process, competitor and geography, Reliable information into specific manufacturing processes and technologies, cost structures, operating expenses, revenues and profitability is often unobtainable from published source data, or can only be estimated based on outdated industry sentiment and assumptions . Innovation is considered an important driver of long---term productivity and economic growth. It is argued that countries that generate innovation, create new technologies and encourage adoption of these new technologies grow faster than those that do not. The Automated pap making machine is conceived based on the need for Nigeria to have locally feed consumption. Pap which is commonly consumed both adults and children still been processed using Manuel and crude method, Agidi and akamu are household food commonly eaten in all region of the country. It is principally processed by women and children and Manuel method used has limited potential of this staple food and adversely affected the income of the crop of person involved in its production. Akamu is a breakfast porridge that is very common in most African countries. What name you call these creamy, corn porridge, depends on what part of Africa you live in. In Nigeria and Cameroon; they it is named *pap, Akamu, or Ogi.* In South Africa, and Ghana it is disguised as; porridge, Millie pap or koko. Four major component were designed to enhance production capacity and reduced contamination with human and environment. These components are washing, grating sieving and pressing/dewatering units.it is model design provides for independents operation of each unit. The essence is to encourage flexibility in the purchase these machine can be couple together using the transfer units at consumer's convenience. It has the capacity to produce 32kg//loading but it operates as a continues process. Once each unit operation is complete more product can be turned in to continuous the process. the estimated time for the production is 1kg/min. Material stainless steel and other standard components for construction are available locally. The machine was designed using solid work/solid edge design software and suitable material selection was done before the couplings and construction of parts. The efficiency of the machine, its associated cost of production and the product obtained after few minutes of Grinding were outstanding, thereby, making the design acceptable and cost effective.

KEYWORDS: Design, Innovation, Manufacturing Costing, Akamu and Machine.

1. INTRODUCTION

Designers need manufacturing cost information when designs have specific cost goals, [1] but also when the most suitable manufacturing processes for a given part must be identified and the part must be optimized for those processes. Designers must therefore be able to estimate the cost of the various concepts to do trade-off studies. An important, although not obvious, benefit of cost estimation, is that it helps the designers to systematically consider the manufacturability of their designs. By necessity, the designer has to consider each of the major manufacturing operations required, including number of set-ups required, tool access, etc. Therefore, a cost estimate can be seen as a quantitative manufacturability analysis [2]. Experienced designers often rely on unwritten guidelines to optimize designs' manufacturability and to estimate their manufacturing cost. Even though design experience is very valuable, it also has limitations. Illustrated in table 1.

Our Global Manufacturing Cost Analysis Team [3] has a proven track record of conducting site analysis across multiple geographies and chemical processes which includes detailed analyzes of product and site-specific

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manufacturing, marketing, sales and technical costs. Manufacturing cost is the sum of costs of all resources consumed in the process of making a product. The manufacturing cost is classified into three categories: direct materials cost, direct labor cost and manufacturing overhead. [4]

Direct materials cost

Direct materials are the raw materials that become a part of the finished product. Manufacturing adds value to raw materials by applying a chain of operations to maintain a deliverable product. There are many operations that can be applied to raw materials such as welding, cutting and painting. It is important to differentiate between the direct materials and indirect materials

Direct labor cost

The direct labor cost is the cost of workers who can be easily identified with the unit of production. Types of labor who are considered to be part of the direct labor cost are the assembly workers on an assembly line

Manufacturing overhead

Manufacturing overhead is any manufacturing cost that is neither direct materials cost or direct labor cost. Manufacturing overhead includes all charges that provide support to manufacturing.
Manufacturing overhead includes
Indirect labor cost:

1. The indirect labor cost is the cost associated with workers, such as supervisors and material handling team, who are not directly involved in the production.
2. Indirect materials cost: Indirect materials cost is the cost associated with consumables, such as lubricants, grease, and water, that are not used as raw materials.
3. Other indirect manufacturing costs: include machine depreciation, land rent, property insurance, electricity, freight and transportation, or any expenses that keep the factory operating

Boothroyd and Dewhurst method, described in Boothroyd et al. [5]. The parameters in the cost model are obtained from Ulrich and Pearson (1998) or publicly available data Manufacturing Content

The manufacturing content

consists of the set of attributes of design that drive manufacturing cost. The details of the attributes considered within manufacturing content are as follows:

1. Assembly content (measured in hours): the time required to assemble the parts into the product. The Boothroyd-Dewhurst method for manual assembly is used for estimating the assembly time (see discussion in the following section).
2. Purchased parts (measured in US$): the cost of purchasing standardized components such as screws, washers, bearings, motors, etc.
3. Sheet metal use (measured in kg): the mass of sheet metal consumed for each part. The mass of sheet metal is converted to equivalent mass of mild steel through the ratio of metal cost to mild steel cost.
4. Sheet metal processing time (measured in hours): the total processing time for each sheet metal part.
5. Sheet metal press requirements (measured in kN-hours): the sum of maximum press force multiplied by the press cycle time for all sheet metal parts.
6. Sheet metal tooling fabrication time (measured in hours): comparison of size and complexity to dies.
7. Plastic use (measured in kg): the mass of plastic parts with allowance for mass of sprues and runners. The mass of resins is converted to the mass of polypropylene with equivalent cost. The equivalent mass of polypropylene is used to calculate the cost of plastic used in the product.
8. Molding processing time (measured in hours): the sum of time required for molding of plastic parts.
9. Molding machine requirements (measured in kN-hours): the sum of clamp force times mold cycle time for all plastic parts.
10. Total plastic mass (measured in kg): the mass of all plastic parts in the product. This parameter is used for energy cost calculation.
11. Mold fabrication time (measured in hours): the total amount of time required for mold fabrication for all plastic parts in the product.
12. Tooling lead-time (measured in weeks): the latency between the initiation and completion of tooling.

13. Number of parts (count): the total number of parts in the product.
14. Number of molded parts: the number of molded plastic parts.
15. Number of unique parts: the number of unique parts in the bill of materials.
16. Number of fasteners: the number of fasteners in the product. [7] illustrated in table 2

Innovation is considered an important driver of long---term productivity and economic growth. It is argued that countries that generate innovation, create new technologies and encourage adoption of these new technologies grow faster than those that do not. Nation see innovation as important, it is a driver of economic growth ,it is linked increased welfare, the creation of new types of job and the destruction of old ones ,in a recent book Bumol noted that virtually all of the economic growth that has occurred since eighteenth century is ultimately attributable to innovation[8]

As stated before, both 'design' and 'innovation' studies do not include a generally agreed definition of the concept of 'design innovation.' However, certain studies, which discuss the relationship between 'design' and 'innovation,' refer to such a concept. While discussing 'design' as a strategic tool for competitive advantage and eventually market success, Walsh et al. [8] refer to a similar concept. They mention "new designs enhancing product quality but involving no technical change," through which they discuss incremental improvements in quality of a product or service that are less risky and expensive, short term, therefore constitute less a venture for the producer [8].

Oakley's [9] definition of design includes the definition of 'design innovation'. According to him, design effort is devoted to "help turn an invention into a successful innovation – or to extend the usefulness of an existing innovation." He also describes this effort as a "fine-tuning to achieve a result that suits our needs more accurately." At this point, Oakley [9] exemplifies his definition . Oakley [9] also points out that 99 percent of the new products in the market are a derivation of an existing application, thus emphasizes the importance of design effort in terms of introducing novelties by extending the usefulness of the existing innovation [10]

The Japanese and Chinese have earned the respect of the rest of the World for their local dishes and traditional cuisine because they are proud of their heritage and pass the knowledge of their nutritional benefits from generation to generation. [11] Traditionally processed Ogi, Akamu or Pap with the distinctive sour taste is a great partner to Fried Plantain, Nigerian Pancake, Akara, Fried Yam, Puff Puff etc. Any of these when combined with Akamu, makes a great breakfast meal. Akamu is also a great baby food.

In Nigeria, we usually add evaporated milk to Akamu meals so the main requirement is that the akamu/ogi/pap is thick after preparation so that when the milk is added, a perfect consistency will be achieved. Akamu is a breakfast porridge that is very common in most African countries. What name you call these creamy, corn porridge, depends on what part of Africa you live in. In Nigeria and Cameroon; they it is named *pap, Akamu, or Ogi* . In South Africa, and Ghana it is disguised as; porridge , Millie pap or koko.In this recipe, corn is left to soak for a couple of days till tender, then it is finely ground in a food processor, passed through a sieve and left outside to ferment and voila –Akamu processing are illustrated in fig 1

2. LITERATURE REVIEW

In the last few years, there have been a number of contributions to the academic design literature by studies on design innovation or other issues within the design innovation framework [12] [13]. Nevertheless, most of the time, design innovation has been referred to as a substitute for terms such as design, innovation, innovative design

Design

In its broadest context, 'design' is defined as "the purposeful or inventive arrangement of parts or details." (The American Heritage Dictionary; 2000). According to ICSID[14], 'design' is "a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles" as "the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange" [14]. The design activity comprises various subordinate areas and activities, which address a diversity of concerns.

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Even though the theory of innovation originates from the theory of economics and studies on technical change, and technical change or 'invention' is mostly recognized to trigger innovations, some studies refer to 'design' as the core of the innovation process [15][16] These studies emphasize the role of 'design' as the innermost part of the innovation process. While Freeman [15] mentions that innovation entails resources such as R&D and design; [16] highlights the central role of design in the innovation process. According to OECD, [16[design is "the very core of innovation…the moment when a new object is imagined, devised, and shaped in prototype form."

Lorenz [17] emphasizes the emerging central role of 'design' at a strategic perspective. According to him [17], "the old weapons for achieving real differentiation have become inadequate. No longer can comparative advantage be sustained for long through lower costs, or higher technologies. The design dimension is no longer an optional part of marketing and corporate strategy, but should be at their very core."

Design Innovation

As previously stated, both 'design' and 'innovation' studies do not include a generally agreed definition of the concept of 'design innovation.' However, certain studies, which discuss the relationship between 'design' and 'innovation,' refer to such a concept. While discussing 'design' as a strategic tool for competitive advantage and eventually market success, Walsh et al. [18] refer to a similar concept. They mention "new designs enhancing product quality but involving no technical change," through which they discuss incremental improvements in the quality of a product or service that are less risky and expensive, short term, therefore constitute less a venture for the producer (Walsh et al. [18]. Oakley's [19] definition of design includes the definition of 'design innovation'. According to him, design effort is devoted to "help turn an invention into a successful innovation – or to extend the usefulness of an existing innovation." He also describes this effort as a "fine-tuning to achieve a result that suits our needs more accurately." At this point, Oakley[19] exemplifies his definition . Oakley [19] also points out that 99 percent of the new products in the market are a derivation of an existing application, thus emphasizes the importance of design effort in terms of introducing novelties by extending the usefulness of the existing innovation. Another perspective that emphasizes the role of design in incrementally improving the qualities of an innovation is the concept of "robust design" (Rothwell and Gardiner, [20]. A number of identical conceptual models have been used in various studies, for which a 'robust design' (or the equivalent concept) is a design that employs an existing technology, but opens up a new user segment or a competitive advantage in the market. Rothwell and Gardiner [20] mention the concept of 're-innovation' through which producers create "a special type of design capable of evolving into a design family of variants which meet a variety of changing market requirements." This perspective also explains the 'reinnovation' or the 're-design' activity as "combining the existing with the new" (Rothwell and Gardiner, [20] [21]

Maize was introduced to Africa from the Americas between the 16th and 17th century. Before this, sorghum and millet were the staple cereals in most of sub-Sahara African. Maize was readily accepted by African farmers as its cultivation was very similar to that of sorghum but with significantly higher yields. Eventually, maize displaced sorghum as the primary cereal in all but the drier regions. The full replacement of these crops with maize took place in the latter half of the twentieth century [22]In Malawi, they have a saying 'chimanga ndi moyo' which translates to 'maize is life[23]Nshima/nsima is still sometimes made from sorghum flour though it is quite uncommon to find this. Cassava , which was also introduced from the Americas, can also be used to make nshima/nsima, either exclusively or mixed with maize flour. In Malawi nsima made from cassava (chinangwa) is localized to the lakeshore areas, however, when maize harvests are poor, cassava nsima can be found all over the country. [24]

3. COMPUTER AIDED DESIGN

CAD began as an electronic drafting board, a replacement of the traditional paper and pencil drafting method. Over the years it has evolved into a sophisticated surface and solid modeling tool. Not only can products be represented precisely as solid models, factory shop floors can also be modeled and simulated in 3D. It is an indispensable tool to modern engineers. Engineers use CAD to create two− and three− dimensional drawings, such as those for automobile and airplane parts, floor plans, and maps and machine assembly While it may be faster for an engineer to create an initial drawing by hand, it is much more efficient to change and adjust drawings by computer. In the design stage, drafting and computer graphics techniques are combined to produce models of different parts. i. Using a computer to perform the six−step 'art−to−part' process: The first two steps in this process are the use of sketching software to capture the initial design ideas and to produce accurate engineering drawings. Next, engineers use analysis software to ensure that the part is strong enough. Step five is the production of a prototype, or model. In the final step the CAM software controls the machine that produces the part, during the design of the machine and the drafting, software was used to draw the orthogonal views. . Illustrated in fig 1,5-6

4. VIRTUAL PRODUCTS

There are a myriad number of uses that can be made of the virtual product created through PSM(Product Specification Management consists).. In the manufacturing or build phase, the "as-built" virtual product is immediately available and can be transmitted to customers and other parties in the supply chain who need the information about the product to assure themselves that the product is actually being created to the required specifications and Customer requirement [25] illustrated in fig 1

Mesh

Li et al propose the Optimal Transportation Mesh free (OTM) method to discretize the variational framework. The OTM method is constructed through the integration of optimal transportation theory for time discretization with Local Maximum Entropy (LME) meshfree interpolation and material point sampling. The material point of OTM method is similar to the quadrature point of the FEM method, which provides a stable way for numerical integration. The nodes and material points are initialized by a conforming finite element mesh of the whole domain. The node of the finite element mesh is initialized as the node of the OTM method, while the quadrature point of the finite element mesh is initialized as the material point. The connectivity between material points and nodes is initialized by the connectivity of the finite element mesh. Then the connectivity is dynamically reconstructed throughout the simulation by using a search algorithm based on the deformation-dependent geometrical information, illustrated in fig 2-4 below.

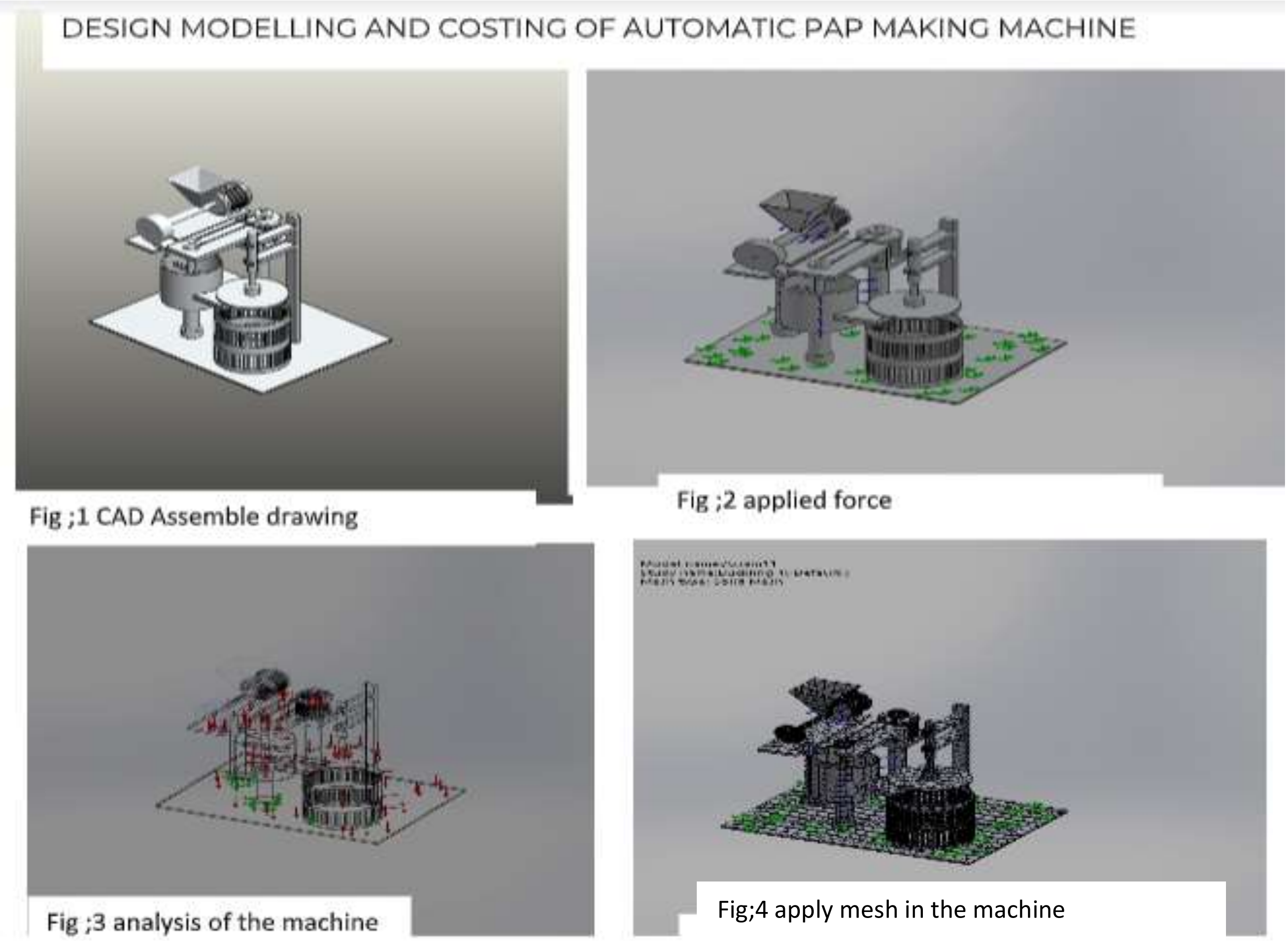

Fig ;1 CAD Assemble drawing

Fig ;2 applied force

Fig ;3 analysis of the machine

Fig;4 apply mesh in the machine

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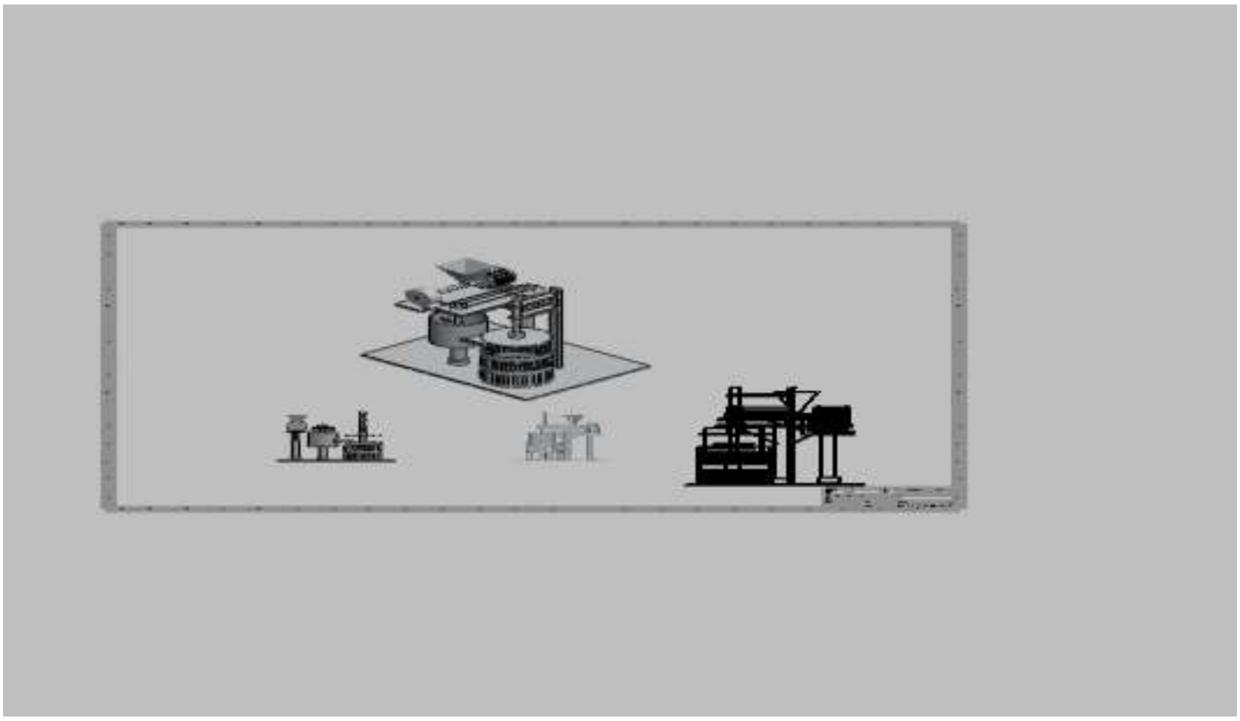
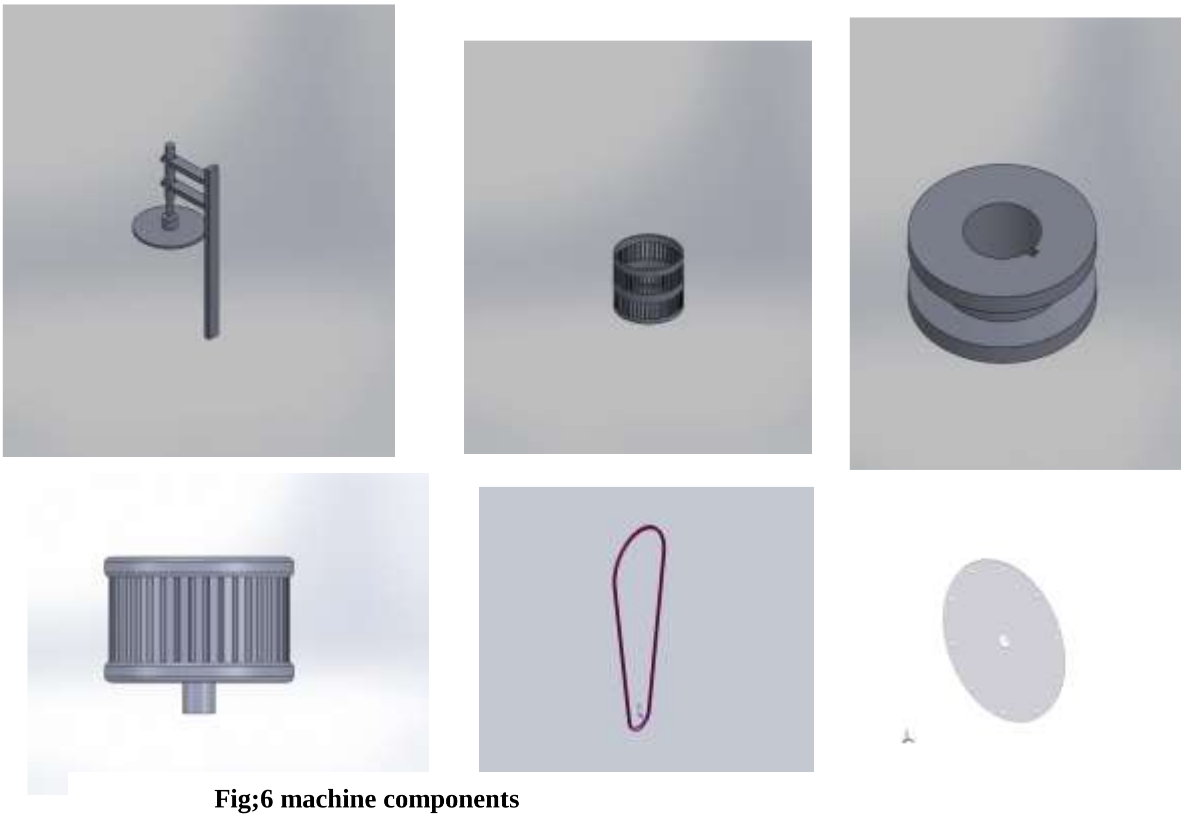


Fig:5 multiply views of the machine



Fig;6 machine components

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Component	Configuration	Material Cost (USD/Assembly)	Manufacturing Cost (USD/Assembly)	Total Cost (USD/Assembly)
drum only	Default	3.20	169.54	172.74
hopper slim	Default	1.91	21.15	23.06
motor stand	Default	5.82	16.94	22.75
Structural	Default	5.08	16.55	21.63
drum stirrer	Default	3.23	15.61	18.84
Hopper stand	Default	4.83	13.55	18.38
motor assembly	Default<As Machined>	0.38	14.15	14.53
only motor	Default<As Machined>	0.37	14.15	14.52
screw coveyor1	Default	0.06	5.73	5.79
Belt1-2^general assembly	Default	0.02	5.61	5.63
Total		**24.90**	**292.98**	**317.88**

Table ; 1 costing

Calculated Parts	Method	Quantity	Part Cost (USD/Assembly)	Total Cost (USD / Assembly)	Costing Template
Hopper stand [Default]	Multibody	1	18.38	18.38	multibodytemplate_default(englishstandard).sldctc
screw coveyor1 [Default]	Multibody	1	5.79	5.79	multibodytemplate_default(englishstandard).sldctc
structural [Default]	Multibody	1	21.63	21.63	multibodytemplate_default(englishstandard).sldctc
base [Default]	Machining	1	0.93	0.93	machiningtemplate_default(englishstandard).sldctm
drum only [Default]	Machining	1	172.74	172.74	machiningtemplate_default(englishstandard).sldctm
only motor [Default<As Machined>]	Multibody	1	14.52	14.52	multibodytemplate_default(englishstandard).sldctc
motor stand [Default]	Multibody	1	22.75	22.75	multibodytemplate_default(englishstandard).sldctc
drum stirrer [Default]	Multibody	1	18.84	18.84	multibodytemplate_default(englishstandard).sldctc
pulley [Default]	Machining	1	2.82	2.82	machiningtemplate_default(englishstandard).sldctm
Belt1-2^general assembly [Default]	Machining	1	5.63	5.63	machiningtemplate_default(englishstandard).sldctm
motor assembly [Default<As Machined>]	Multibody	1	14.53	14.53	multibodytemplate_default(englishstandard).sldctc
hopper slim [Default]	Multibody	1	23.06	23.06	multibodytemplate_default(englishstandard).sldctc
drum for motion [Default]	Machining	1	2.82	2.82	machiningtemplate_default(englishstandard).sldctm
stirrer [Default]	Machining	1	4.95	4.95	machiningtemplate_default(englishstandard).sldctm
Total			329.40	329.40	

Table 2 machine costing

5. DISCUSSIONS

It is general knowledge that those who are engaged in agriculture are the poor in comparison with those who engaged in other sector of the economy in Nigeria that is to say their standard of living is so low that shortage of funds to enable them facilities has been a major handicap in the development [24]. Investigation shows that the few available small scale processing equipment are not very efficient. This lack of efficiency small scale processing equipment to farmers has increased the inability of their farming activities. Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs. While individual products are usually measured by weight, their varying densities make measuring overall agricultural output difficult. Therefore, output is usually measured as the market value of final output, which excludes intermediate products such as corn feed used in the meat industry. Simulation tools enable us to be creative and to quickly test new ideas that would be much more difficult, time consuming, and expensive to test in the lab. (Jeffrey D. Wilson, Nasa Glenn Research Center) It also help us reduce cost and time-to-market by testing our designs on the computer rather than in the field. [26]

"Akamu" (ogi) is a name given to a popular fermented cereal porridge made from these crops: maize, sorghum, millet, to mention but a few. "Akamu" is a nutritive diet that is mostly eaten at infancy as a weaning food. But adults also enjoy this delicacy. Production of "akamu" is carried out mainly by local producers, and there is risk of high microbial contamination which often makes the food products undesirable due to the presence of organisms that cause food spoilage, food poisoning or food intoxication in the food product (Awada et al., 2005). Food poisoning and infection can lead to fatal consequences in infected individuals, and the major risk factors are attributable to contaminated raw materials, poorly controlled fermentation conditions, poor personal/environmental hygiene and post processing handling. More so, production of maize pap is laborious, time-consuming and the issue of locality differences which results in the variable nature, non-specified quality indices, unknown shelf life and lack of safety indices of the "akamu" products. Therefore, there is every need to develop methods to extend the shelf life while maintaining the economic, safety, nutritional and total quality of "akamu" in order to meet the increasing demand and also proffer health benefits to the final consumers. [27]

Manufacturing Cost Analysis enhances the client's understanding of key cost drivers and process differentiators associated with a specific product line and assesses how they vary by technology, process, competitor and geography. Shown in table 1 and 2. Reliable information into specific manufacturing processes and technologies, cost structures, operating expenses, revenues and profitability is often unobtainable from published source data, or can only be estimated based on out-dated industry sentiment and assumptions. Manufacturing Cost Analysis program is designed to provide an 'evidence' or 'fact-based' profit and loss statement for one or more manufacturing sites and/or product lines. [28]

Innovation is considered an important driver of long---term productivity aeconomic growth. It is argued that countries that generate innovation, create new technologies and encourage adoption of these new technologies grow faster than those that do not. Nation see innovation as important, it is a driver of economic growth ,it is linked increased welfare, the creation of new types of job and the destruction of old ones ,in a recent book Bumol noted that virtually all of the economic growth that has occurred since eighteenth century is ultimately attributable to innovation.

It is against this background that our research theme was derived and the advantages are as following[28]Pap called Ogi by the Yorubas , Akamu by the Igbos and Kira Masara by the Hausas have the following health benefits:

- Easy Digestion: With pap, there is nothing like constipation or indigestion because the cereal digests easily. This is why in Nigeria; sick persons are given pap to drink.
- Superb for Breastfeeding: taking pap supplies the body with sufficient liquid the body needs, this is why women breastfeeding babies in Nigeria take pap as it enhances the supply of milk from the breast.
- Energy Booster: pap is mostly taken as a breakfast meal, this is because it is light and does not weigh the body down but instead increases the body's energy level because it supplies carbohydrate.
- Reduces Risk of High Blood Pressure: pap contains a high amount of Potassium and zero amount of sodium. This makes it perfect for lowering blood pressure.

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- Contains Vitamins: corn used to make pap contains lots of vitamins which includes; Vitamin A, Vitamin C, Vitamin B5, B3, B1. It also contains Potassium, Zinc, Magnesium, Phosphorus, Chromium, Selenium and so on.
- Since pap is mostly taken with other varieties like Akara, Moi-Moi, Fish and so on, taking this cereal helps to nourish the body. [30]

6. CONCLUSION/RECOMMENDATIONS

Refers to the effort of ensuring that the engineering design satisfies the consumer needs and complies with the manufacturing facilities of a company, ie.. machines, staff knowledge and resources available. However, most current DFM specialists advocate a team approach in applying DFM. Essentially, this means that design and Manufacturing people work to gain benefits of manufacturing knowledge and experience that the designer may guarantee that the product is both functional and Manufacturability[31]

It is therefore recommended that the following strategies should be mapped out and embarked upon in order to reduce to a tolerable level or totally eliminate microbial contamination on “akamu”. Some of these strategies have been approved as regulations by the Department of Health Education & Welfare, Public Health Services and Food & Drug Administration (FDA) and local agencies over current trends in the manufacturing, processing, packaging or holding of human food generally referred to as GMPs (Good Manufacturing Practices). - The local producers of “akamu” should be enlightened on the importance of observing these regulations – GMPs. - Infected personnel should be restricted from participating in the production of “akamu”. - Portable water should be used during the production of “akamu”. - Better preservative techniques should be used to prolong shelf life of “akamu” product. - The regulatory agencies especially the NAFDAC (National Agency for Food and Drugs Administration and Control) should ensure strict compliance to the regulations by the grass root. - The government of the federation should map out extensive public enlightenment campaign especially in the rural areas to educate both the local producers and consumers of “akamu”. Finally, the government should also introduce the use of probiotics to the local producers of “akamu” and sell to them at a very subsidized rate. The probiotics are meant to mimic the normal microbial flora in humans like the ones found on breast milk that offer protection against diseases. The most frequently used ones for now are Lactobacillus species and Bifid bacterium species. More research should be done to introduce more of these probiotics.

It is possible to state that innovations are and will surely remain to be a means for organizations to survive in today's turbulent and highly competitive environment. Based on this discussion the following policy are necessary, efforts should be made to adopt and popularize the manufacturing cost, design-DFX, DFA, DFE etc especially for the benefits of mankind who make up a great numbers of Nation’s population. If, the machine design innovations/costing are adopted, the problem in food and other agricultural processing equipment will be minimized and hunger/poverty will be eradicated in Nigeria, the project is successful, therefore software design should be encouraged in our institution of higher learning.

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