

Development of Machine Paper Plate from Natural Fibres

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Abstract: In recent years, natural fibers appear to be the outstanding materials which come as the viable and abundant substitute for the expensive and nonrenewable synthetic fiber. Natural fibers like sugar cane, banana, oil palm, kenaf and coir has been used as reinforcement in thermoplastic composite for applications in consumer goods. Thus, the idea of this machine development is to produce the paper plate using natural plant that is pineapple leaves. Many machines have been introduced to assist the making of paper plates in the market. However, the existing machine is expensive and it is difficult to be handled. Therefore, this project is intended to overcome the stated problem by designing and developing a paper plate machine. The designed machine has following a basic design process started from identification of needs, conceptual design, embodiment design and detail design. Meanwhile, for proof-of-concept testing, the proposed machine concept has been developed to test the functionality and capability. Several activities have been included in discussion. As a summary, the paper plate machine has been successfully designed and verified based on the proof-of-concept testing. This machine can be used for producing paper plates using dumping of pineapple leaves.

Keywords: Natural fiber, product design, design for functionality

1. Introduction

In recent years, natural fibers appear to be the outstanding materials which come as the viable and abundant substitute for the expensive and nonrenewable synthetic fiber. Natural fibers like sugar cane, banana, oil palm, kenaf and coir has been used as reinforcement in thermoplastic composite for applications in consumer goods, furniture, low cost housing and civil structures. Pineapple leaf fiber (PALF) is one of them that have also good potential as reinforcement in thermoplastic composite. It is the objective of the current research to characterize PALF and to investigate the effect of fiber treatment on the mechanical properties of PALF reinforced polypropylene (PP) composite. Figure 1 show the example of pineapple used.



Fig. 1 - Example of pineapple used

PALF was prepared from raw pineapple leaf. It was then chemically treated to hinder the water content. Both PP and



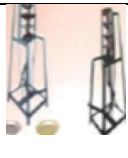
PALF were compounded using two roll mill machines prior to compression moldings via hot press machine to form a sheet. After forming the composite sheet, samples were prepared for tensile test (ASTM D638), flexural test (ASTM D790) and impact test (ASTM D256). Scanning Electron Microscope (SEM) was used to investigate the miscibility between the fiber and matrix. It was found that PALF contain 87.56% hollow cellulose, 78.11% alpha cellulose, 9.45% hemicellulose and 4.78 % lignin.

The chemical constituents obtained were in the range to data reported in literatures. It was also observed that the flexural modulus and strength of treated PALF reinforced PP composite increased linearly with increment of fiber loadings. This trend was similar for impact strength where it exhibited a slight reduction at the initial stage but increased later as the fiber loading increased. The study has demonstrated that the optimum fiber loading for the best performance of the composite achieved was 30 wt%. This was clarified further by SEM where fibers and matrix have shown better miscibility at 30 wt% of treated PALF.

1.1 Existing Product Identification

Benchmarking is the process of comparing the performance or capacity of any enterprise, measured in several ways. It also defined as a continuous process to find and the implement best practices that will lead to superior performance. Benchmarking process can be applied to all facets of a company’s business, be it in products, services or business process. Additionally, benchmarking will make a company’s operation lean, and improve quality and productivity (Table 1).

Table 1 - Benchmarking of Product Specification of Existing Product

Description	Product 1	Product 2	Product 3
Product example			
Item code	Esskay - HPPM	Esskay - MPPM	Esskay - FOPPM
Power (kw)	220 V	N/A	220 V
Capacity (pieces/hrs)	1200	500	900

Dimensions typically measured are quality, time and cost. Benchmarking is useful because it helps planners and designers identify the area in which their organization is needs improvement. In the process of best practice benchmarking, management identifies the best firms in their industry, or in another industry where similar processes exist, and compares the results and processes of those studied (the "targets") to one's own results and processes. In this way, they learn how well the targets perform and, more importantly, the business processes that explain why these firms are successful. Benchmarking is used to measure performance using a specific indicator (cost per unit of measure, productivity per unit of measure, cycle time of x per unit of measure or defects per unit of measure) resulting in a metric of performance that is then compared to others.

2. Proposed Design of Paper Plate Machine

2.1 Conceptual Design

2.2.1 Component decomposition and function analysis

The analysis for each component is needed in order to get the optimum function for this machine. For our project, we are focus to a several components that need carefully choose to ensure our machine is running perfectly. As example, we focus the material selection for body, mold, cutter and puncher. The main components that use in our project are illustrated in Figure 2 and function analysis in Figure 3.

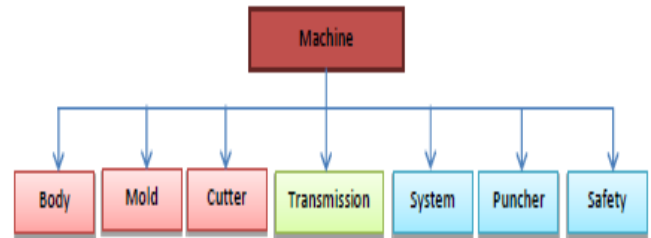


Fig. 2 – Component Decomposition

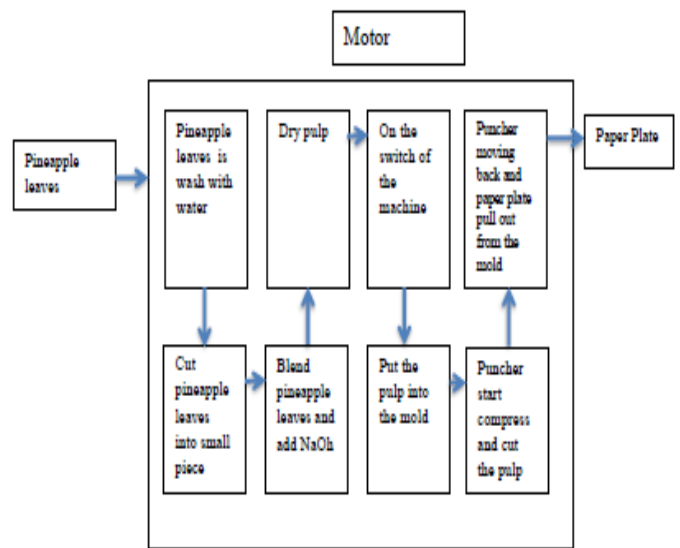


Fig. 3 – Function Analysis of Paper Plate Machine

2.2.2 Concept Selection

From the list concept above, we decided to choose concept 4 which are Body (steel) + mold (stainless steel) + puncher (stainless steel) + system (motor) + cutter (round knife) + safety (emergency button) + transmission (gear).

2.2.3 Product sketching

After done with the concept selection, all selected concepts are combined into a complete structure. Figure 4 shows the preliminary sketch of the proposed concept.

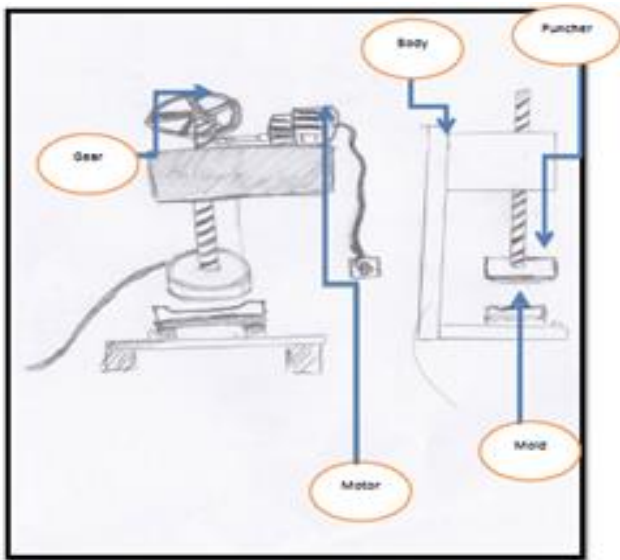


Fig. 4 – Sketching of the proposed concept

2.2 Embodiment Design

2.2.1 Product Architecture

The architecture of the product can be a key driver of the performance of the manufacturing firm. It is because the architecture of the product is very important in managerial decision making. Product architecture is particularly relevant to the research and development (R&D) functions of a company because architectural decisions are made during the early phases of the innovation process. Product architecture also can be described as the plan of the function for a product is allocated to physical components.

Schematic diagram of the product describes the step for making the product from raw materials until produce the desire product. For this project, the process to produce paper plate is shown in Figure 5.

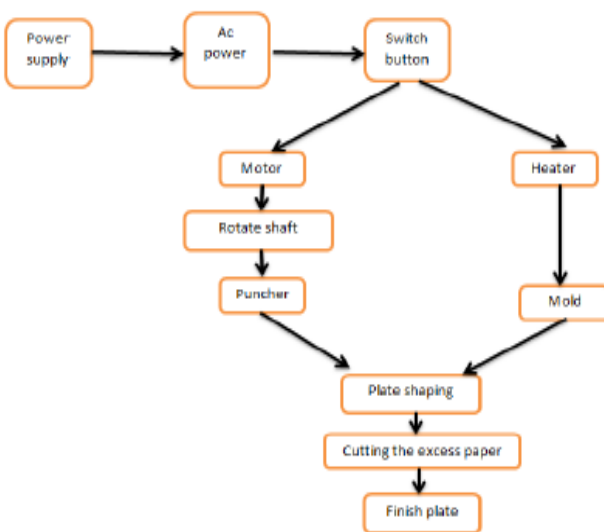


Fig. 5 – Schematic diagram of Paper Plate Machine

2.2.2 Product Configuration

Configuration design is set of design where a set of main components is given and an assembly of selected components is choosing. The characterization of a design parts need to satisfy a set of requirements and obeys a set of

constraints. Sometimes an optimization of characterization may be given that defines an ordering upon possible solutions.

▪ Standard and special-purpose part

A standard component is usually an individual part, manufactured in thousands or millions, to the same specification such as size, weight, material, and others. Meanwhile, special purpose parts are components that its operations are limited to the acquisition of specific function. The special purpose components are usually subsidiary components. Table 2 shows the list of standard and special purpose part.

Standard Part	Quantity
On/off switch	1
Plug	1
Motor	1
Special Purpose Part	Quantity
Shaft	1
Puncher	1
Mold	1

2.3 Detail Design

2.2.1 Detail Drawing

A detail drawing is the most important drawing for fabrication work. A detail drawing is a drawing of a part giving a complete and exact description of its form, dimensions, and construction. Detail drawing must be concise, in that they convey only the information needed to create the part, such as the size, type of material, finish, tolerance and any special instruction. In other word, all information needed to produce the part should be on the detail drawing. In our project, the detail drawing as follows.

Part drawing shows the detail of part design in term of its dimension and material. Overall, the paper plate machine has 15 parts as shown in Figure 6.

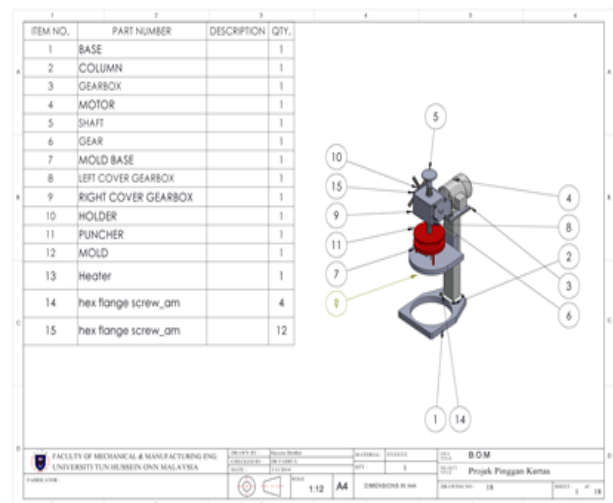


Fig. 6 – Exploded view of Paper Plate Machine

Assembly drawing is a detail drawing that shows how all of the parts interact in mating to each other to form a useful machine. It will allow us to identify the exact connection between each part. A complete assembly drawing is presentation of the product or structure put together, showing all parts in their operational positions. An assembly drawing is needed for all products or inventions that have more than one part. Assembly drawing of Paper Plate Machine is illustrated in Figure 7.

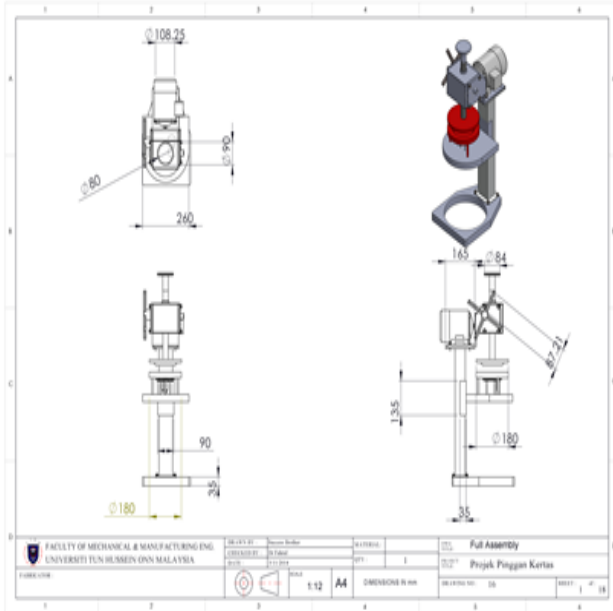


Fig. 7 – Assembly drawing of Paper Plate Machine

3. Prototype Development

Prototyping is the process of building a system model. In terms of an information system, prototypes are employed to help system designer build an information system that intuitive and easy to manipulate for end users. Prototyping is an iterative process that is part of the analysis phase of the system development life cycle.

In addition, we have collected the data required before we generate the system of the prototype. We study on the data obtained and come out with the system generated. Before we constructed the prototype, selection of material and part has been conducted by selecting the most suitable materials and parts of the prototype.

3.1 Process Involved

In relation to validate the problem formulation of our project and to show the appearance and exterior of our finished product, an actual scale of model of the proposed product was fabricated.

❖ Material Used

The body of the prototype of Paper Plate Machine was fabricated by using cardboard because it is easy to fabricated compare to using stainless steel. Figure 8 shows the material used which is cardboard in our prototype



Fig. 8 - Material used to produce prototype

❖ Measurement process

Cardboard was measure by using ruler to the actual scale of prototype and mark down using pencil. The measurements involve every single part in our prototype. Process of measurement and marking are shown in Figure 9.

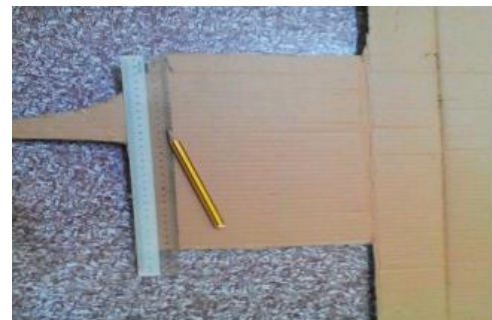


Fig. 9 – Measurement process

❖ Cutting process

The sheet of cardboard was cut out into the required dimensions using scissors and knife. The required dimension was referred to the intended scale of the product where scale 1:2 has been applied. Figure 10 shows the cutting process from cardboard.



Fig. 10 - Cutting Process

❖ Joining process

The pieces of cardboard with the intended dimensions were cut out from cardboard part by part and assembled together become the complete prototype by joining them using hand glue gun. The part by part joining process illustrated in Figure 11.



Fig. 11 - Joining Process

3.2 Prototyping (Assemble) Process Time

The pieces of cardboard with the intended dimensions were cut out from cardboard part by part and assembled together become the complete prototype by joining them using hand glue gun. The part by part joining process illustrated in Figure 12.

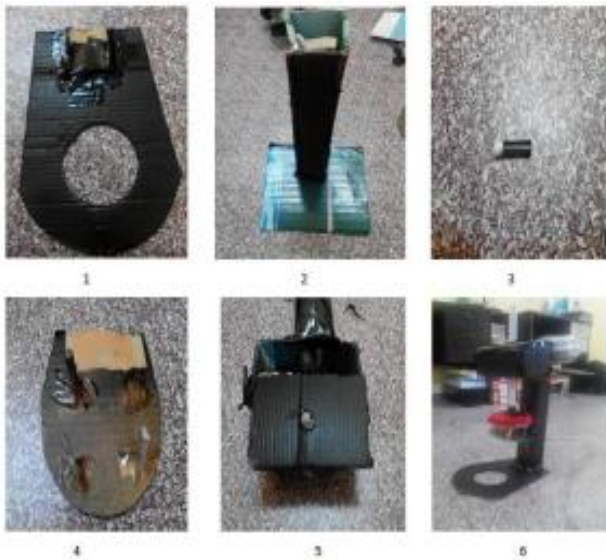


Fig. 12 - Assembly Process

3.3 Final prototype

Figure 13 shows the final product prototype of Paper Plate Machine. This prototype had been developed successfully by following all the design specification and achieved the objective by completing the development of Paper Plate Machine.



Fig. 13 - Prototype of Paper Plate Machine

4. Conclusion

The idea of invention for this project, started when the surplus pineapple leaves that does not use any more is going to waste. This situation causes pollution to the environment due to uncontrolled dumping the surplus pineapple leaves. Besides that, plastic usage in large scale in order to produce the plastic plate will give an impact to the environment because it will cause pollution. This is because the plastic is a material that difficult to recycle and only one way to extinguish the plastic that is burn this material. Air pollution will happen when this situation is occurred.

Several ideas have been generated in order to overcome this problem. The idea of this machine to produce the paper plate using natural plant that is pineapple leaves. When we use natural plant such as pineapple leaves as our raw material, the usage of the plastic will decrease. So the dependable sources plastic in industry as raw material will super ceded by natural sources. The products from natural sources are easy to extinguish. This situation will prevent natural environment from pollution. By using G.E. Dieter's design process model, we are successfully understood about design process that we should use in order to help us to complete our project.

In order to get information to improve our project, we were constructing a questionnaire by using a Google Docs. The information that we get from questionnaire was analyze and several factors or material selections were considered to help our project complete successfully. By referring the analysis of questionnaire to 30 respondents, we decided to use stainless steel as our material selection for body and shaft. For puncher, mold and round knife we also used stainless steel as our material selection. Besides that, we decided to use motor system to operate the puncher. Also, we decided to use a gear system to transmit the forces from the motor to the puncher system. For safety precaution, we use emergency button that attached to body of machine.

For economical factor for this project, we suggested that Paper Plate Machine is worthwhile and affordable for Small and Medium Industry (SMI) or farmer of pineapple due to several reasonable reasons. First of all, Paper Plate Machine will help this type of people or this industry to generate side income from their waste product such as pineapple leaves. These waste products will be the raw materials in order to produce natural plates. By selling this natural plate, the company will gain more profit and only need one worker to

handle this machine. So, even this machine is not too cheap but still affordable to buy due to this side income generating factor.

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