POSSIBLE ADOPTION OF TRIZ AND FEA FOR ENHANCING PINEAPPLE LEAF FIBER EXTRACTOR MACHINE PERFORMANCE: A MINI REVIEW

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***Abstract*— Pineapple fibres have the potential to be used in a variety of industrial applications; however, the laborious procedure required to separate fibres from pineapple leaves prevents their utilisation to their full potential. Extracting fibres from leaves using the machines which are at present available is an inefficient process because it requires much time to complete. In this study, we discuss the 'Theoria Resheneyva Isobretatelskehuh Zadach' (TRIZ) approach and the contribution that finite element analysis (FEA) made to the development of a product innovation. In the future, this research may be used to improve existing pineapple extractor machines. It is suggested that by combining both TRIZ and finite element analysis are able to fasten the research and development process to a better pineapple extraction machine.**

Keywords*— *Theoria Resheneyva Isobretatelskehuh Zadach' (TRIZ), finite element analysis (FEA), pineapple leaf fiber extraction machine

I. INTRODUCTION

There are several methods available to extract fiber from plant parts such as leaf and stem, as affirmed in literature. The methods applied include chemical retting process, mechanical method (roller and bladder system), hand scraping etc. Yusof, Yahya & Adam (2014) compared Josapine pineapple leaf fiber (PALF) extraction using hand scraping and mechanical extraction methods [1]. The researchers found that the diameter of fiber extracted using hand scraping method was larger compared to the mechanical method, measuring 90.7µm and 75.7µm respectively. Apart from that, the fiber diameter of mechanically extracted Thailand's PALF was 45.8µm [2]. Besides that, the retting process is also available for fiber extraction from the pineapple leaf. It is reported that the chemical retting process is fast, taking only 10-15 days while water retting took up to one month [3]. Table 1 shows the summary of the fiber extraction method for pineapple leaf.

TABLE 1. THE EXTRACTION METHOD FOR PINEAPPLE LEAF.

Methods	Time taken per leaf (hour)
Hand scrapping	0.5
Mechanical method	~ 0.02
Water retting	720
Chemical retting	240 - 360

II. FIBER EXTRACTOR MACHINE

1) A fiber extractor machine is a mechanical tool that is used to extract the fiber from the pineapple leaf. Through the prior art search, several pineapple leaves machines served different kinds of operations and functions. Table 2 shows the patent number of the machine and its design claims [4-9]. The purpose of having a mechanical extractor machine compared to the conventional hand-scraping method is to fasten up the process of fiber extraction).

TABLE 2. A LIST OF PINEAPPLE LEAF FIBER MACHINE

Applicant No.	Title	Claim
CN201720921937U 20170728	Full-Automatic Pineapple Blade Fiber Extraction Machine	1. The number of the conveyor belts is two; the two conveyor belts are arranged in parallel. 2. the number of blades is 12 pieces 3. a hairdryer is arranged between the knife ball and the pinch wheel. 4. the slag discharging port is disposed of under the squeegee round wheel 1 and the sprocket wheel 2. the clip wheel round wheel 1 and the clip blade round wheel 2 have the same size and structure.
CN201714 10268 20170603	Pineapple Leaf Fiber Stripping Device With Function Of Intelligently Feeding According To Amount Of Input Material	The stripping knife roll has a rotation speed of 1600 r/min and the number of stripping blades is 14 pieces. The anvil arc is 55mm long.
CN201427 93983U 20141216	Pineapple Leaf Fiber Splitting Machine	A cutting fixed knife
CN201426 40910U 20141031	Pineapple Leaf Fiber Packing Device	Packaging of pineapple fiber

Applicant No.	Title	Claim
CN201314 24154 20130918	Pineapple Leaf Harvesting And Fiber Extracting Combined Harvester	Blade harvesting, fiber extraction and defibration are concentrated on 1 machine and complete Scraping mechanism is scraping the rotor, matches with notch board in this scraping rotor bottom, and the gap between the two is 1-2mm.
PI 201370142 9	An Apparatus For Extraction Of Leaf Fiber	Have a number of blades ratio of 9-10:6-7 and the upper blade rotates at a speed greater than the lower blade.

From existing patents, it was found that several types of machines were used for the extraction of pineapple leaf fiber. Most of the machines have the extraction part that is used to crunch leaf surfaces leaving only the fiber. The function of some machines only involve post processing of fiber, and equipped with a cutter and packaging process. Table 3 shows the list of the patented pineapple machines with their specific functions. It is critical to invent a new design with functions suiting the objectives and budget of the current research. As shown in Table 3, the extraction mechanism is critical for an extractor machine, and therefore the design of the extraction component is crucial to demonstrate efficiency in producing fibers of the desired quality.

TABLE 3. PRIOR-ART-SEARCH RELATED TO PINEAPPLE LEAF FIBER MACHINE

P.I Number	Extraction	Conveyor mechanism	Cutter	Packaging	Leaf harvesting
CN201720921937U 20170728	Y	Y			
CN20171410268 20170603	Y	Y			
CN20142793983U 20141216		Y	Y		
CN20142640910U 20141031				Y	
CN20131424154 20130918	Y	Y			Y
PI 2013701429	Y				

III. PROBLEM SOLVING METHOD -TRIZ METHODOLOGY

TRIZ is the acronym for Russian words 'Theoria Resheneyva Isobretatelskehuh Zadach' which means 'Theory of Inventive Problem Solving' in English. TRIZ is used widely in various applications and it is a useful problem-solving tool [10]. The TRIZ concept can be understood through a mathematical 'operator' expression. If a mathematical problem has a general solution, a specific value is included to obtain specific solutions. TRIZ offers general solutions to the problems, allowing the user to find quick solutions to the related problems supported by some principles. Stage 1 involves the translation of identified problems into the language of TRIZ to provide insightful information to further assist problem-solving. Stage 2 involves structuring the problem into typical TRIZ contradictions by conducting contradiction analysis, which is one of the most effective problem-solving tools. The TRIZ includes 40 knowledge-based inventive principles aimed at eliminating the contradictions. Stage 3 involves evaluation of the generated ideas by using the unique TRIZ criteria, which is the ideal final result. The final output is a list of possible innovative conceptual solutions to the identified problems [10].

To gain a competitive advantage in an increasingly challenging world, companies need to remain at the forefront by boosting productivity and enhancing efficiency to outperform their competitors. To gain competitiveness, the companies need to procreate new products or eliminate the existing contradictory states. TRIZ methodology is one of the most effective scientific methods employed by managers or inventors across the field of industry, as shown in Table 4 [11-16].

TABLE 4. SUMMARY OF TRIZ APPLICATION IN INDUSTRY

Method(s)	Objective(s)	Application	Reference
TRIZ and ANP methods	The TRIZ method is applied at the conceptual design phase to search for possible solutions in designing improved wooden cross-arm of transition towers. After identifying the search for the best design by employing the ANP method.	Civil	Sharaf et al., 2020
TRIZ	The TRIZ method is employed to redesign the walker to improve the ergonomics of the product.	Medical	Laksana, Setyanto,& Herdiman, 2021
TRIZ	To design the modular plantar orthosis system for the shoe.	Medical	Ramírez-Rios et al., 2021
TRIZ	To design a finger grip enhancer for the elderly.	Medical	Tan, Ng, & Noor, 2021
FEPAM model (function-effect-process-action-mechanism model) and TRIZ	To redesign the distribution robot so that the robot is more convenient to operate and reduce labour intensity	Robotic	Jiahao et al., 2021
TRIZ	The application of TRIZ in SME's business operation to be more sustainable and competitive in future.	Company	Lin & Chen, 2021

IV. FINITE ELEMENT ANALYSIS

Computer invention has revolutionised engineering practice. The tedious hand drawing of a product design, a design analysis through hand calculation had been replaced with computer-aided design (CAD) and computer-aided engineering (CAE) software. Together CAD, CAE, and computer-aided manufacturing (CAM) have dramatically changed the landscape of engineering.

The finite element method (FEM) is one of the computational tools for CAE that are versatile as it is one of the most powerful modern 'calculators' used by engineers. Through virtually testing of a product, finite element analysis (FEA) helps the engineers to get a picture of their design and improve the design if necessary at an early stage of product development.

TABLE 5. APPLICATION OF FEA IN MULTI-APPLICATION

Material	Method	Investigate parameter	Application	Outcome	Reference
Carbon Fiber Reinforced Polymers (CFRP)	ANSYS® Workbench Explicit Dynamics	To demonstrate elastic waves during drop weight impact	Composite	The FEM shows the deformation and strain waveform experienced by the composite agree with numerical study through finite difference method.	Andleeb et al., 2021
Steel (seat frame)	Ansys threedimensional Ls-Dyna simulation and metamodel	Pre-design optimization of bus seat strength	Automotive	The seat design optimization had been made between two methods, the results show that there is about 0.1% to 3.0% variation for the following studied parameter thickness, sections and length of structural elements	Arroba et al., 2019
Steel and aluminium	ANSYS® Workbench Explicit Dynamics	To investigate the best shape of the frontal head tube for impact resistance	Automotive	The studies investigate the effect of shape for car's frontal head tube during impact by analyzing the Peak Force (PF) and Specific Energy Absorption (SEA) through ANSYS® simulation. The study found out that the best shape to have the highest impact absorption is Hexa-foiled shape.	Acharya et al., 2020
Sheet Copper alloy	ANSYS® Workbench Explicit Dynamics	To analyse the sheet copper alloy material equivalent stress, shear stress, internal energy and total deformation	Automotive and aerospace	The sheet copper alloy material behaviour subjected downward punched in was investigated through deformation, internal energy and shear stress against time using ANSYS® Workbench Explicit Dynamics	Das & Pani, 2021
Kevlar, Carbon fiber, Glass fiber and Ballistic-steel	ANSYS® Workbench Explicit Dynamics	To study the penetration resistance of the composite material.	Defence	The study was conducted to analyse the impact resistance of laminated composite subjected to the ballistic impact test. The study simulation find out that Kevlar/carbon fiber/ steel Composite has the best impact resistance compared to Kevlar/Steel composite, Carbon Fiber/ Steel Composite, carbon fiber/glass fiber/steel composite, and Kevlar/glass fiber/ steel composite	Narendiranath et al., 2021

FEA is widely applied in various fields including materials science, biomedical engineering, geophysics, and many other emerging fields in recent years, as shown in Table 5 [17-21]. The application of FEA in the design cycle is driven by market pressure, as it is beneficial for companies aiming to make better products with less development costs and shorter time-to-market. ANSYS® Workbench is an advanced engineering simulation technology software that is commercially available to conduct the FEA. The software can solve problems in structural, thermal, acoustics, and multi-physics aspects. Moreover, it is geared toward improving productivity and ease of use among engineering teams.

V. CONCLUSION

By implementing TRIZ and finite element analysis, the time taken for producing new improve product can be shorten besides saving the total cost of research and development. Therefore, it is expected that by improving the current pineapple leaf fiber extractor machine, the users are able to extract the fiber from the leaf within a shorter period of time using less energy, whereas fibers extracted using the existing design need to be combed after extraction process to separate it into single strands of fiber.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or

could be perceived to have influenced the work reported in this article.

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