Chapter in Book

Lawnmower Design and Development with a TRIZ-Informed Perspective

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Abstract: *Lawn mower is a mechanical device with moving blades that cut the lawn to an even length to maintain grassy area on slope. The flail mower, a type of lawnmower, is intended to be upgraded so that it may function effectively and efficiently on slopes up to 55 degrees. The application of three innovative TRIZ principles as problem-solving solutions has a good effect on minimising environmental impact. The first use of Principle #2 "Separation" is to separate the tractor from the flail mower in order to lessen the burden while climbing the steep slope of the hill. Second, accordance to Principle #12 "Equipotentiality", condition of work is modified by substitution of tractor to another mechanical equipment such as winch to aid the mower climb the incline hill. Thirdly, the "Local Quality" principle was applied because the winch is necessary when the tractor is removed. Many modifications were required to make it easier for the operator to raise the winch up the hill. In accordance with Principle No. 3, the mount was positioned similarly to a backpack so as to allow the operator's safe ascent of the hill. Using the TRIZ approach, agricultural designers can use this design to create a sustainable and optimal shape and configuration for lawnmower machines. According to JKR standards and requirements, it may be utilised in landscape, roadways, etc. Substantial implications from the usage of the TRIZ approach during conceptual design will be withheld, breaking the mindset and drastically lowering the time necessary for the design process, while delivering new theories, new ideas, and new views for future appropriate design.*

Keywords: TRIZ; inventive principles; innovation; lawn mower

1. INTRODUCTION

Four-fifths of Malaysia consists of jungle and wetlands. Peninsular Malaysia consists of high, wooded mountains and coastal lowlands to the east and west. As seen, there are a number of roadway segments with steep hills on the left and right sides. On the hills, there are grassy patches that must be maintained. Regular mowing of the grass is necessary to prevent the encroachment of bushes. A lawnmower is an indispensable piece of equipment for maintaining a tidy lawn. The lawnmower is a machine with moving blades that maintains the appearance of the lawn by cutting it to an even length. There are numerous sorts of lawnmowers, each suited for a specific purpose. Hand-powered lawn mowers are an option for small lawns in residential areas and gardens. Big lawns complement the larger ones effectively. Massive lawns, such as those seen on golf courses and in city parks, require the largest, tractor-drawn lawnmowers. It is essential to become familiar with the repairable and replaceable components of the lawn mower. These parts, as well as the parts and their features, are described in the owner's manual for the lawn mower.

There are various types of lawnmowers on the market now, including push mowers, riding mowers, robotic mowers, remote-controlled mowers, etc. Each of these technologies has its own pros and disadvantages. Because there are numerous hills in Malaysia, the problems centred on the topography there. This is evident, for instance, on the highway's borders and slope. On steep slopes, the numerous mowers available on the market are incapable of cutting the grass. The current approach employed by contractors is bagged lawn mowers, which pose a risk to the operator if they fall. Even though ride-on mowers have the most advanced technology on the market, they cannot be used on slopes steeper than 45 degrees. Thus, this study examines the conceptual design of the lawnmower and the application of TRIZ (Theory of Inventive Problem Solving) as a problem-solving technique to improve the design of the lawnmower in order to address this issue.

2. METHOD & MATERIAL

Each type of lawnmower's most important design elements is analysed to determine which may be improved most efficiently. A comparison of currently available lawnmower models based on a variety of characteristics. Table 1 serves as a guide for collecting technical data on various types of lawnmowers in order to differentiate them and select the most appropriate type for the principal design. The flail mower was chosen as the starting point for study and mower improvement based on the accompanying table. In industrialised nations, slopes with grass or other ground cover are mowed with flail mowers. A tractor-drawn flail mower is unable to cut grass on steep or mountainous slopes. So, with a few tweaks for technological progress, the TRIZ principle can be applied to the production of flail mowers.

Table 1. Technical data comparison of various type of lawn mower

Type of Lawn Mower	Horse Power (Hp)	Cutting Height (mm)	Cutting Width (mm)
Backpack (Bafang BF139)	1.7	-	280
Wheeled Rotary (Powerplus POWXG60225)	6.65	25-27	508
Roller Rotary (STIHL MB655VR)	3.7	20-75	530
Hover (Bushranger HM16H-4)	2	12.7-76.2	406
Cylinder (Allet Kensington 17K)	1.9	6-32	430
Ride On (Poulan Pro Model)	17.5	Max 101.6	1066.8
Flail (Landpride FM2060)	55	19.05-101.6	1524

3. FINDINGS

To choose the most effective inventive concept, it is necessary to comprehend the restrictions, as only then can solutions be designed to maximise the constraints. Many design factors must be condensed into a more comprehensible constraint model for the connection of constraints (Khairul Manami et al, 2015). As is evident, academic institutions and private businesses engaged in product creation have extensively implemented and studied invention principles. The purpose of research on innovative principles is to enhance the definition of principles by compiling a comprehensive list of related examples and customising definitions for other fields (computer science, business, chemistry, manufacturing, and others). Using the TRIZ technique, a database containing the answer (principle) capable of resolving contradictions, the design is improved. It is necessary to enhance ergonomics, safety, and affordability without sacrificing the quality of the final output. Depending on the topic at hand, the concepts of separation, local quality, and equipotentiality are selected.

3.1 Principle 2: Separation

Principle 2 mandates the separation of interfering parts or properties from an object or the extraction of the only necessary part or property. This approach has been implemented in numerous industries, such as dentistry, where tooth extraction is a common example, and medicine, where ampoules are used to divide drugs for individual usage (see Figure 1).

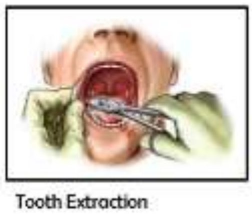
Symbol	Example
	

Figure 1. Principle 2: Separation

3.2 Principle 3: Local quality.

Principle 3 stipulates that an object's structure and external environment (or external impact) must be transformed from uniform to non-uniform. The objective is to provide optimal conditions for each component to efficiently perform its purpose, resulting in distinct yet complementary functions. Figure 2 depicts two examples of this principle in action: a pencil with an eraser and a hammer with a nail puller or claw.

Symbol	Example
	

Figure 2. Principle 3: Local Quality

3.3 Principle 12: Equipotentiality

Principle 12 describes how modifying operational conditions can minimise the need to work against a potential field (e.g., eliminate the need to raise or lower objects in a gravity field). As depicted in Figure 3, this approach can be applied to a variety of devices, including hydraulic stylist chairs that can be raised or lowered with the tap of a foot and massage chairs that can be modified via electronic control. This technique eliminates the need for physical energy when lifting or lowering objects, making the gadget more convenient and user-friendly.

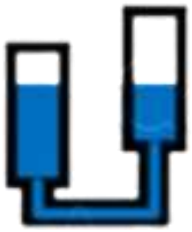
Symbol	Example
	

Figure 3. Principle 12: Equipotentiality

4. DISCUSSION

Dutta P.P. et al. (2016) discovered few technological distinctions amongst mowers. Malaysia lags behind other countries in terms of mowing technology. Owing of its versatility in cutting a variety of grasses, the flail mower served as the primary mower in this study. The flail mower is capable of cutting through a variety of ground cover types; however, industrialised nations limit its use for mowing grass on steep slopes. This study recommends employing TRIZ to enhance the lawnmower's slope capabilities to a maximum of 55 degrees. The lawnmower was created using three ground-breaking TRIZ principles: separation, local quality, and equipotentiality. These suggestions were intended to enhance the performance and safety of flail mowers.

The investigation begins by applying Separation Principle 2. As shown in Figure 4, this method is utilised to detach the tractor from the flail mower, so reducing the weight of the mower and allowing it to cross the steep slope of the hill.

Figure 4. Illustration Concept Principle 2: The Tractor is Detached from the Flail Mower

In accordance with Principle 12, Equipotentiality, the tractor was replaced with a new piece of mechanical equipment. As indicated in Figure 5, a winch was chosen to assist the mower in climbing the slope. With this new technique, the designer was able to address the issue of cutting grass on steep slopes between 40 and 55 degrees, which was incompatible with earlier lawnmower designs. A crucial feature of lawnmower design, the addition of the winch to the flail mower design enhanced the safety of the worker operating the backpack mower.

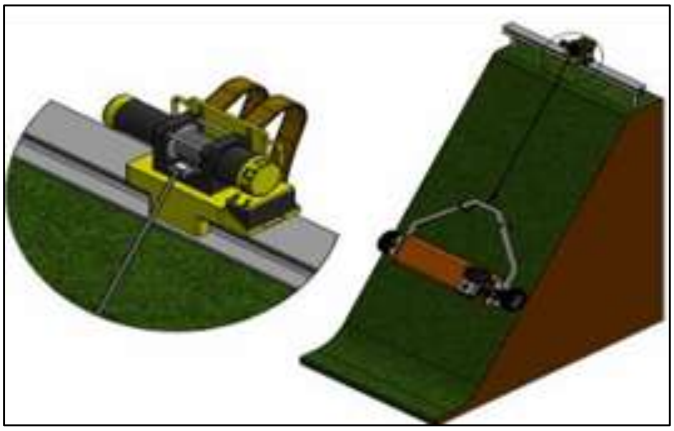


Figure 5. Illustration Concept Principle 12: The Mower Aided with Winch

After the tractor was removed, Local Quality Principle 3 was implemented since the winch became essential. Various adjustments were required to make it easier for the operator to raise the winch up the hill. In accordance with Principle 3, as indicated in Figure 6, the mount is positioned similarly to a backpack to facilitate the operator's safe ascent of the slope. Following this technique, the designer may increase the local quality of the winch system, making it easier and safer to use. This is especially crucial given the steep slopes required in mowing grass, which can offer substantial safety threats to the operator.

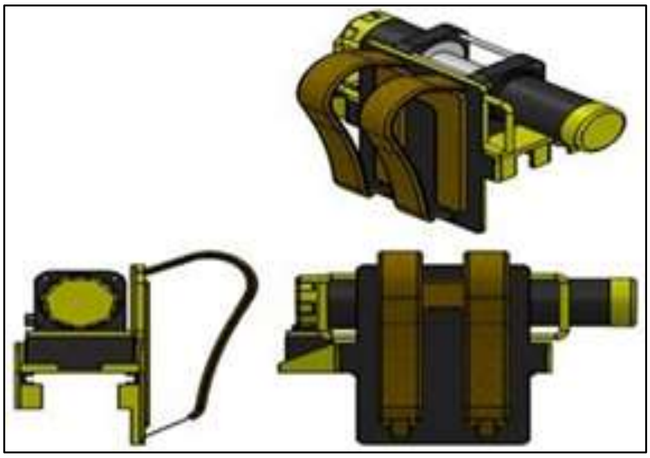


Figure 6. Illustration Concept Principle 3: The Mount Positioned Similarly to Backpack

This study gives significant insights into the application of TRIZ concepts to the design of lawnmowers and illustrates the possibilities for future technical improvements in this field.

5. CONCLUSION

This study sheds insight on the global expansion of lawnmower technologies, with options ranging from tiny to advanced. It highlighted the uncommon use of lawnmowers in Malaysia relative to other developing nations. The flail mower was chosen as the principal design, and it was suggested that its utility may be enhanced by incorporating characteristics from other types of lawnmowers. This analysis also revealed that no existing lawnmower design is capable of cutting grass on slopes steeper than 45 degrees, leading to the proposal of a new lawnmower design employing the TRIZ methodology that is capable of cutting grass on slopes between 40 and 55 degrees. Using TRIZ principles such as separation, local quality, and equipotentiality, this study focuses on building a revolutionary backpack lawnmower that reduces the danger of injury to the operator. This study closes by emphasising the significance of ongoing innovation in lawnmower technology to increase its applicability in a range of scenarios and maintain worker safety.

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