Design and Analysis of Thresher Machine Flywheel using SolidWorks Simulation

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DECLARATION

I declare that this thesis entitled “Design and Analysis of Thresher Machine Flywheel using SolidWorks Simulation” is the results of my own research except as cited in the references.

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Design and Analysis of Thresher Machine Flywheel using SolidWorks Simulation

ABSTRACT

During the harvesting process, the flywheel of a thresher machine is an essential component that plays a significant part in ensuring that grain is separated in a manner that is both efficient and dependable. The capacity of the machine to store energy, to supply inertia, and to allow power transfer all contribute considerably to the overall performance and productivity of the machine in agricultural activities. The flywheel, which is a vital component of the power transmission system of the machine, plays a role in the maintenance of a steady rotational speed, the provision of inertia to the machine's moving elements, and the guarantee of smooth operation under different loads. For satisfying the requirements of contemporary farming methods, the design and optimization of flywheels for thresher machines will continue to be crucial. This is because automation in agriculture is continuing to improve.

Keywords: Flywheel, Thresher Machine, Strain, Displacement, Stress

Reka Bentuk dan Analisis Roda Jala Mesin Thresher menggunakan Simulasi SolidWorks

ABSTRAK

Semasa proses penuaian, roda tenaga mesin pengirik merupakan komponen penting yang memainkan peranan penting dalam memastikan bijirin diasingkan dengan cara yang cekap dan boleh dipercayai. Keupayaan mesin untuk menyimpan tenaga, membekalkan inersia, dan membenarkan pemindahan kuasa semuanya menyumbang dengan ketara kepada prestasi keseluruhan dan produktiviti mesin dalam aktiviti pertanian. Roda tenaga, yang merupakan komponen penting dalam sistem penghantaran kuasa mesin, memainkan peranan dalam penyelenggaraan kelajuan putaran yang stabil, penyediaan inersia kepada elemen bergerak mesin, dan jaminan kelancaran operasi di bawah beban yang berbeza. Untuk memenuhi keperluan kaedah pertanian kontemporari, reka bentuk dan pengoptimuman roda tenaga untuk mesin pengirik akan terus menjadi penting. Ini kerana automasi dalam pertanian terus bertambah baik.

Kata Kunci: Roda Tenaga, Mesin Pengirik, Terikan, Anjakan, Tekanan

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CHAPTER 1: INTRODUCTION

1.1 Background of Study

The flywheels used in threshing machines are essential components of the agricultural equipment used to separate cereals from their respective stalks or husks. These flywheels, which are typically located within the power transmission system, serve multiple crucial functions.

Flywheels serve as reservoirs for the accumulation and storage of rotational energy first and foremost. This capacity enables the continuous delivery of power, enabling an uninterrupted and consistent source of rotational force, thereby mitigating fluctuations and guaranteeing a consistent power supply for the duration of the threshing machines (Samshette & Swami, 2015) operation. In addition, the substantial mass of the flywheels endows them with a substantial amount of rotational inertia. This attribute substantially contributes to the performance stability of the machine. By preventing abrupt changes in rotational velocity, the flywheels act as stabilizing agents, facilitating seamless and harmonious operation and compensating for any disturbances caused by variations in power supply or resistance during the grain separation process.

In addition, the flywheels are predominantly responsible for power transmission (Reddy & Keerthi, 2016) within the threshing machine. By establishing mechanical connections, such as belts or gears, between the flywheels and the engine or motor driving the apparatus, the rotational energy stored in the flywheels can be efficiently transferred to drive other vital components, such as the threshing drum, sieves, and conveyor belts. This transmission of energy enables these elements to function effectively, resulting in the successful separation of seeds from their stalks or husks.

Lastly, the flywheels' inherent ability to retain rotational energy enables a consistent mechanism for delivering power to the thresher machine. By compensating for the intermittent nature of the power source, which is typically an internal combustion engine, the flywheels assure a constant and consistent power supply. Consequently, the threshing machine can operate with increased efficiency, dependability, and effectiveness during the process of grain separation.

The design and specifications of flywheels in threshing machines can vary based on several variables, including the scale of the machine, its power requirements, and its intended application. Typically, (Vardaan & Kumar, 2022) flywheels are fabricated from cast iron or steel, as these materials possess the necessary strength and durability to withstand the significant stresses and forces that arise during the operation of the threshing machine.

In conclusion, the flywheels that are incorporated into threshing machines play crucial roles in ensuring optimal performance. By storing and distributing rotational energy, stabilizing the machine's operation, facilitating power transmission, and ensuring consistent power delivery, these flywheels contribute to the success and functionality of the thresher machine.

This research project known as Flywheel utilizing SolidWorks Simulation has the overarching goal of enhancing the threshing machine's productivity, functionality, and dependability. The threshing machine is a piece of agricultural machinery (Reddy & Keerthi, 2016) that is utilized in the process of separating grain harvests from the stalks, leaves, and husks that they contain. The machine is normally made up of a few different components, the most notable of which are the threshing drum, the concave, and the flywheel. The flywheel is an essential part of the machine since it serves to store energy from the machine's rotation and keeps the machine's rotational speed stable.

The purpose of this study is to find solutions to some of the problems that have been identified with the design and the materials selection (Vardaan & Kumar, 2022) of the flywheel found in threshing machines. The necessity of both of the purposes of the study of the flywheel design is to make sure it attains the highest possible energy storage capacity and transfer efficiency while simultaneously reducing its weight. The overall weight of the threshing machine can be reduced with the use of a lightweight flywheel design, which in turn makes the machine more maneuverable and less difficult to move.

Another obstacle to overcome is making sure the flywheel is reliable and long-lasting under a variety of loading situations, such as centrifugal forces and rotating speed. The failure of the flywheel because of poor design or material selection can result in considerable damage to the threshing machine and possibly represents a safety concern to the operator.

The research suggests the use of SolidWorks Simulation, a computer-aided engineering software program, to build, analyze, and design the flywheel that is utilized in threshing machines to meet the issues that have been presented. Engineers can model and simulate the behavior of the flywheel under a variety of loading circumstances thanks to the SolidWorks Simulation tool. This enables them to identify potential failure sites and optimize the design to increase the flywheel's performance and longevity.

Using SolidWorks Simulation, the research intends to improve the design and analysis of the flywheel, with the end goal of contributing to the creation of threshing machines that are more effective, reliable, and secure. The findings of the study have the potential to inform the design and engineering practices of the agricultural machinery business, which will, in the end, improve agricultural productivity and sustainability.

1.2 Problem Statement

The thresher machine flywheel requires precise and adequate materials. Flywheels store energy. Energy is stored when supply exceeds demand and released when demand exceeds supply. Flywheels store energy. During the thresher's power stroke, it receives energy from the power source. Flywheel rotation stores energy for later use.

The problem that must be investigated is the selection and comparisons of flywheel material in threshing machines. In agriculture, threshing devices are commonly used to separate grains from harvested crops. The flywheel is a vital component of the threshing machine, (Samshette & Swami, 2015) as it is responsible for supplying rotational energy and maintaining a constant operational pace. Nevertheless, the selection of flywheel material has a substantial effect on the overall performance and efficacy of the machine.

So, in this study, we need to compare the alternative material such as glass fiber type- S, alloy steel and carbon steel to the original material for the flywheel which are cast iron (Vardaan & Kumar, 2022). This is because using cast iron material for flywheel thresher machines can lead to brittleness and deformation problems. Flywheel materials should have strength, stiffness, density, thermal characteristics, and fatigue resistance.

1.3 Objective

The objective of the research is:

1. To define the mechanical properties for each suggestion material for a flywheel in the thresher machine
2. To make a comparison of cast iron replacement materials for the manufacture of flywheels in the thresher machines in terms of stress, strain and displacement

1.4 Scope of Study

The scope of study is conducted to achieve the objective that has been mentioned. This research will be conducted at University Malaysia Kelantan Jeli Campus. Using SolidWorks as part of this project's research allows for the replacement of the fundamental materials utilized in the construction of the machine with materials that are more suited for the project. In contrast to other projects and experiments, which must be carried out in a laboratory or workshop and require the assistance of lecturers or laboratory assistants, this research just requires devices such as laptops and software such as SolidWorks. Other projects and experiments must be carried out in a laboratory or workshop. The next thing that needs to be done is to design a 2D and 3D drawing of the flywheel thresher machine using the SolidWorks program, and then either replace the basic material of the machine with a material that has mechanical qualities that are comparable to those of the basic material or replace it with a material that is of a higher quality.

1.5 Significance of Study

The purpose of this study is to change the actual materials for the flywheel thresher machines to material that have similar properties or better quality. The result of this study is supposed to make the flywheel thresher machine high quality and durability. Besides that, the purpose of this study also to make a comparison of cast iron replacement materials for the manufacture of flywheels in the thresher machines in terms of stress, strain and displacement. This is because the flywheel of the threshing machine can be improved in terms of durability, strength and hardness and also by choosing the appropriate material for its construction.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A flywheel is a form of inertial energy storage. It stores mechanical energy and acts as a receptacle, storing energy when the supply exceeds demand and releasing it when the demand exceeds supply. The primary function of a flywheel is to balance out variations in the speed of a shaft caused by force fluctuations. Typically, a flywheel is required when the source of the (Samshette & Swami, 2015) propelling force or load force is variable. Numerous machines have load configurations that vary the force–time capacity throughout the cycle. Different frameworks, such as punching presses, cylinder blowers, IC Engines, and so on, contain flywheels. According to their geometry, there can be two varieties of flywheels. The solid disc flywheel has a hub and a slender disc, whereas the rim-type flywheel has spokes between them. The rim of a flywheel can induce various types of stresses, such as tensile stress due to centrifugal force, tensile bending stress, and contraction stress due to the erratic cooling rate. Because these tensions may be exceptionally high, there is no straightforward method for choosing between them.

2.2 The Making Process for Flywheel in Thresher Machine

Creating a flywheel for a threshing machine requires multiple procedures and considerations. First, a suitable material is chosen based on factors such as strength, durability, and cost. Common alternatives include cast iron, steel, and composites. The desired shape and configuration of the flywheel, typically a solid disk or ring structure with a balanced weight distribution, is then determined. For optimal energy storage, the dimensions and mass of the flywheel are calculated to accomplish the desired moment of inertia. Depending on the selected material and the complexity of the design, the flywheel is then manufactured via techniques such as casting, forging, or machining. The flywheel's rim, (Reddy & Keerthi, 2016) which aids in energy storage, is meticulously designed, either as a solid rim or with spokes to reduce weight. Finally, pulleys or gears connect the flywheel to the thresher's power source, ensuring efficient power transmission. Safety considerations are considered throughout the manufacturing process, such as the implementation of protective guards to prevent accidental contact with rotating parts. The result is a well-designed and meticulously constructed flywheel that plays a crucial role in the threshing machine's seamless and efficient operation.

2.3 Finite Element Analysis (FEA) for Flywheel Thresher Machine

FEA is a computerized numerical technique for analyzing the structural behavior of complex systems or components. FEA can be utilized to evaluate and optimize the design and performance of a flywheel for a threshing machine. (Samshette & Swami, 2015) The flywheel is divided into a finite number of smaller, interconnected elements or meshes for FEA. Each element's material properties and behavior are determined by predetermined mathematical equations. FEA software can simulate the physical behavior of the flywheel under various conditions, including rotational forces, vibrations, and thermal loading, by solving these equations.

By incorporating FEA into the design of a flywheel for a threshing machine, engineers are able to make informed decisions, reduce the need (Vardaan & Kumar, 2022) for physical prototypes, and enhance the flywheel's overall performance, reliability, and safety. It facilitates a thorough comprehension of the flywheel's behavior, resulting in improved design decisions and more efficient threshing machines.

For determining how components or assemblies/components react when subjected to stress, simulation in SolidWorks makes use of methods from finite element analysis. Pressure, force, gravity, centrifugal force, or even loads transferred from prior simulation studies might be utilized as the load. These are all examples of potential loads that could be employed.

Mesh Details

Study name	Static 3* (-Default-)
DetailsMesh type	Solid Mesh
Mesher Used	Blended curvature-based mesh
Jacobian points for High quality mesh	16 points
Max Element Size	8.86353 mm
Min Element Size	2.95448 mm
Mesh quality	High
Total nodes	19900
Total elements	11436
Maximum Aspect Ratio	5.75
Percentage of elements with Aspect Ratio < 3	98.7
Percentage of elements with Aspect Ratio > 10	0
Percentage of distorted elements	0
Number of distorted elements	0
Time to complete mesh(hh:mm:ss)	00:00:05
Computer name	

Figure 2.1: Meshing Information

Figure 2.2: The Meshed Sample

CHAPTER 3: MATERIALS AND METHODS

3.1 Introduction

This chapter will cover and explain about the materials and methods on how the flywheel for thresher machine are made. Due to the a few reasons, the cast iron of solid/disk need to be replaced with a glass fiber type- S. This is because, the (Vardaan & Kumar, 2022) glass fiber type-S can compensate a deformation to decrease centrifugal loading and increase the deformation and also had good compatible material to replace the cast iron in the flywheel. In conclusion, the findings of this research indicate that the energy storage capacity of the threshing machine can be improved by optimizing the geometric design of the flywheel and choosing an appropriate material for the structure.

3.2 Materials

In the beginning, the material used in the manufacture of the flywheel for the thresher machine was cast iron. However, for certain reasons such as problems with high centrifugal loading and low deformation, the material had to be replaced with glass fiber type-S because the characteristics of this material are better compared to cast iron and the impact of the problems experienced in the previous material did not have a high impact on the glass fiber type-S. Besides that, materials like aluminum and steel are also used to make a flywheel for thresher machines but these two materials are not the main materials that need to use since the mechanical properties are not far different from cast iron. For the steel, Flywheels are typically made from various varieties of steel, including carbon steel and alloy steel. Steel has greater strength and durability than cast iron while being lighter in weight. For the aluminum, Aluminum flywheels are lighter than iron or steel flywheels, making them ideal for applications requiring rapid acceleration and deceleration. However, aluminum might not be as durable as iron and steel.

3.2.1 Cast Iron

Cast iron, which typically ranges in weight from 2% to 4% carbon, is a ferrous alloy distinguished by its high carbon content. The material consists predominantly of carbon (C) and iron (Fe), supplemented with trace quantities of other elements to bestow particular characteristics. Utilizing the casting process, in which molten iron is placed into molds to form intricate forms, cast iron obtains its name. The unique characteristics of cast iron are predominantly ascribed to its microstructure, comprising a metallic matrix that is dispersed with graphite particles or nodules. Carbon precipitates in the form of graphite during the solidification process of molten cast iron, giving rise to this microstructure.

The cast iron design makes the flywheel compact and strong. The flywheel can store more energy and rotate more smoothly due to its sturdy design. This improves engine speed consistency and performance. In internal combustion engines, industrial machinery, and heavy-duty vehicles, cast iron flywheels store and regulate rotational energy. They are reliable and suited for high-torque and precision applications due to their design and material qualities.

Table 3.1: Mechanical Properties for Gray Cast Iron

Properties	Values	Unit
Tensile Strength	1.52 X 10^9	$N/m2$
Yield Strength	-	$N/m2$
Elastic Modulus	6.62 X 10^10	$N/m2$
Poisson Ratio	0.27	
Mass Density	7200	$kg/m3$
Shear Modulus	5 X10^10	$N/m2$
Coefficient of thermal expansion	1.2 X 10^ −6	k

3.2.2 Glass Fiber Type -S

Thermal and acoustic insulation are two of the most prevalent applications for fiberglass type -S insulation, which is a particular form of fiberglass insulation that is extensively used in residential and commercial construction in the United States. The cost-effectiveness, lightweight lightness, and good thermal insulating characteristics of fiberglass have contributed to its widespread use as an insulation material. S-glass is a kind of high-performance glass fiber that is principally differentiated from E-glass by the presence of a greater proportion of silica. Oxides of silicon, aluminum, and magnesium are usually found in S-glass because of its composition. When compared to E-glass, S-fiberglass possesses much better tensile strength and elastic modulus, in addition to significantly higher stiffness by around 10%. Additional important properties are a high resistance to temperature, a strong resistance to moisture, and a long fatigue and shelf life. Because it has these features, it is suited for use in applications that are demanding. By way of illustration, it is often used in the aircraft business for cargo liners, gaskets, and many other interior components. Additionally, it is utilized in the automobile sector for the engine portion.

Table 3.2: Mechanical Properties for Glass Fiber Type -S

Properties	Values	Unit
Tensile Strength	4.5 X 10^9	$N/m2$
Yield Strength	4 X 10^9	$N/m2$
Elastic Modulus	9 X 10^10	$N/m2$
Poisson Ratio	0.25	
Mass Density	2600	$kg/m3$
Shear Modulus	3.5 X10^10	$N/m2$
Coefficient of thermal Expansion	7 X 10^ −6	k

3.2.3 4340 Alloy Steel

Steels that are classified as alloy steels are a large group of steels that, in addition to iron and carbon, contain a variety of alloying components. To improve mechanical properties, such as strength, hardness, toughness, and wear resistance, these alloying elements are added to the material. It is usual practice to employ alloy steels in a wide variety of engineering applications due to the adaptability of these materials and their capacity to be adapted to unique requirements. Alloy steels can have different mechanical properties based on the alloying elements and the concentrations of those elements employed.

However, it is possible that alloy steel could be an appropriate material for a flywheel. However, this will depend on the needs of the application. Several criteria, including the intended mechanical qualities, the working circumstances of the system, and the design parameters, all play a role in determining whether alloy steel is suitable for use in a flywheel. For example, this material is high in strength and durability. Alloy steels are well-known for their exceptional strength and long-lasting properties. This is because flywheels are subjected to cyclic loads and high rotational speeds, it is advantageous to choose materials that possess exceptional strength properties.

To offer the requisite strength to withstand the dynamic forces that are involved with flywheel operation, alloy steels can be developed to give that strength. Besides, it is also had its own heat treatment capability. It is common for alloy steels to be heat-treatable, which enables the improvement of mechanical qualities like as hardness and strength. To adjust the material to the specific requirements of the flywheel, techniques like quenching and tempering are examples of heat treatment methods that can be utilized.

Table 3.3: Mechanical Properties for 4340 Alloy Steel

Properties	**Values**	**Unit**
Tensile Strength	7.23 X 10^9	$N/m2$
Yield Strength	6.2 X 10^9	$N/m2$
Elastic Modulus	2.1 X 10^11	$N/m2$
Poisson Ratio	0.28	
Mass Density	7700	$kg/m3$
Shear Modulus	7.9 X 10^10	$N/m2$
Coefficient of thermal Expansion	1.3 X 10^ −5	K

3.2.4 AISI/SAE 1055 Carbon Steel

Carbon steels are a flexible set of alloys that are widely utilized in a variety of industrial applications. AISI/SAE 1055 is a medium carbon steel that is a member of the family of carbon steels. The classification of steel grades is a collaborative effort by the American Iron and Steel Institute (AISI) and the Society of Automotive Engineers (SAE). The "1055" in AISI/SAE 1055 indicates the carbon percentage of the steel, which is roughly 0.55%.

The AISI/SAE 1055 carbon steel is a type of carbon steel that is frequently utilized in engineering applications that demand a compromise between machinability, toughness, and strength. To make an informed decision about whether to use AISI/SAE 1055 in the production of a flywheel, it is necessary to have a thorough understanding of the characteristics of this material and how they influence the overall performance of the flywheel.

Various aspects have been considered in choosing this material as one of the viable options for constructing flywheels for thresher machines. One of the aspects is the amount of the carbon content in this material. Carbon is included in AISI/SAE 1055 at a level of approximately 0.55%. Because of the steel's medium carbon concentration, which contributes to the steel's overall strength and hardness, the steel is suited for applications that demand durability. Besides that, AISI/SAE 1055 is a material that reacts well to heat procedures for treatment. It is possible to improve the mechanical properties of steel by applying heat treatment techniques such as quenching and tempering. These techniques can improve the steel's hardness and strength.

Table 3.4: Mechanical Properties for AISI/SAE 1055 Carbon Steel

Properties	Values	Unit
Tensile Strength	4.25 X 10^9	$N/m2$
Yield Strength	2.8 X 10^9	$N/m2$
Elastic Modulus	2.04 X 10^11	$N/m2$
Poisson Ratio	0.29	
Mass Density	7858	$kg/m3$
Shear Modulus	7.9 X 10^10	$N/m2$
Coefficient of thermal expansion	1.2 X 10^ −5	K

3.3 Mathematic Modelling

For the mathematic modelling in terms of designing the flywheel for thresher machines, the calculation must be made to determine the right parameter for the design. Those a few calculations formula for the flywheel.

Flywheels store energy in the form of kinetic energy. The amount of energy ‘E’ stored in a flywheel varies linearly with moment of inertia ‘I’ and with the square of the angular velocity ‘ω’.

$$E = \frac{1}{2} . I . \omega^2$$

The moment of inertia is a physical quantity, which depends on the mass and shape of the flywheel. It is defined as the integral of the square of the distance ‘x’ from the axis of rotation to the differential mass ‘dmx’

$$I = \int x^2 \, dmx$$

The solution for a cylindrical flywheel of mass ‘m’ and radius ‘r’ will be:

$$I = m r^2$$

And

$$E = \frac{1}{2} m r^2 \omega^2$$

3.4 Methods

The following is a step-by-step method to sketch a drawing of flywheels for thresher machines using SolidWorks Software:

1. Open SolidWorks and start creating an entirely new part file from the beginning.

2. To get started, draw a rough outline of the bottom of the machine. Create the machine base's perimeter by drawing lines, rectangles, and circles with the line, rectangle, and circle tools, respectively. Check to see that the measurements are correct following the specifications of your design.

3. To create a three-dimensional form for the base, use the extrude tool. Indicate the height that you want the extruded region to be and then choose the drawing region.

4. On the uppermost part of the base, sketch the flywheel. To get started, use the circle tool to quickly draw a circle. The correct size of the flywheel should be determined, and the requisite measurements should be used.

5. To create a three-dimensional form for the flywheel, use the tool called extrude. Indicate the thickness that you want the extrusion to have and choose the sketch region that you want to affect.

6. Construct the drum used by the thresher. Draw a circle on the top surface of the base, relatively near to where the flywheel is located. Make any necessary adjustments to the circumference and height of the circle.

7. To create a three-dimensional form for the thresher drum, use the extrude tool in adobe illustrator. Indicate the height that you want the extruded region to be and then choose the drawing region.

8. Draw the other pieces of the machine, such as the feed chute, the separating screen, and any other parts that you feel are necessary to include. Make sure you use the right sketching tools and take accurate measurements for each component.

9. Using the extrude or revolve tool, give the sketched profiles a 3D shape by extruding them or rotating them, respectively, depending on the geometry of the component you are working on.

10. Apply the proper fillets and chamfers to any sharp edges on the machine to give it a more realistic appearance and to smooth out any rough spots. To apply these features, you will need to use the fillet and chamfer tools.

11. Using the text and annotation tools, add any additional details or labels that are required to the sketch.

12. Afterwards, look over the entire sketch one last time to check that it's accurate and make any required changes.

13. After finishing the process of sketching, you may move on to using SolidWorks to apply materials, make assemblies, and generate drawings, set up the draw using FEA or renderings of the flywheels for the thresher machines.

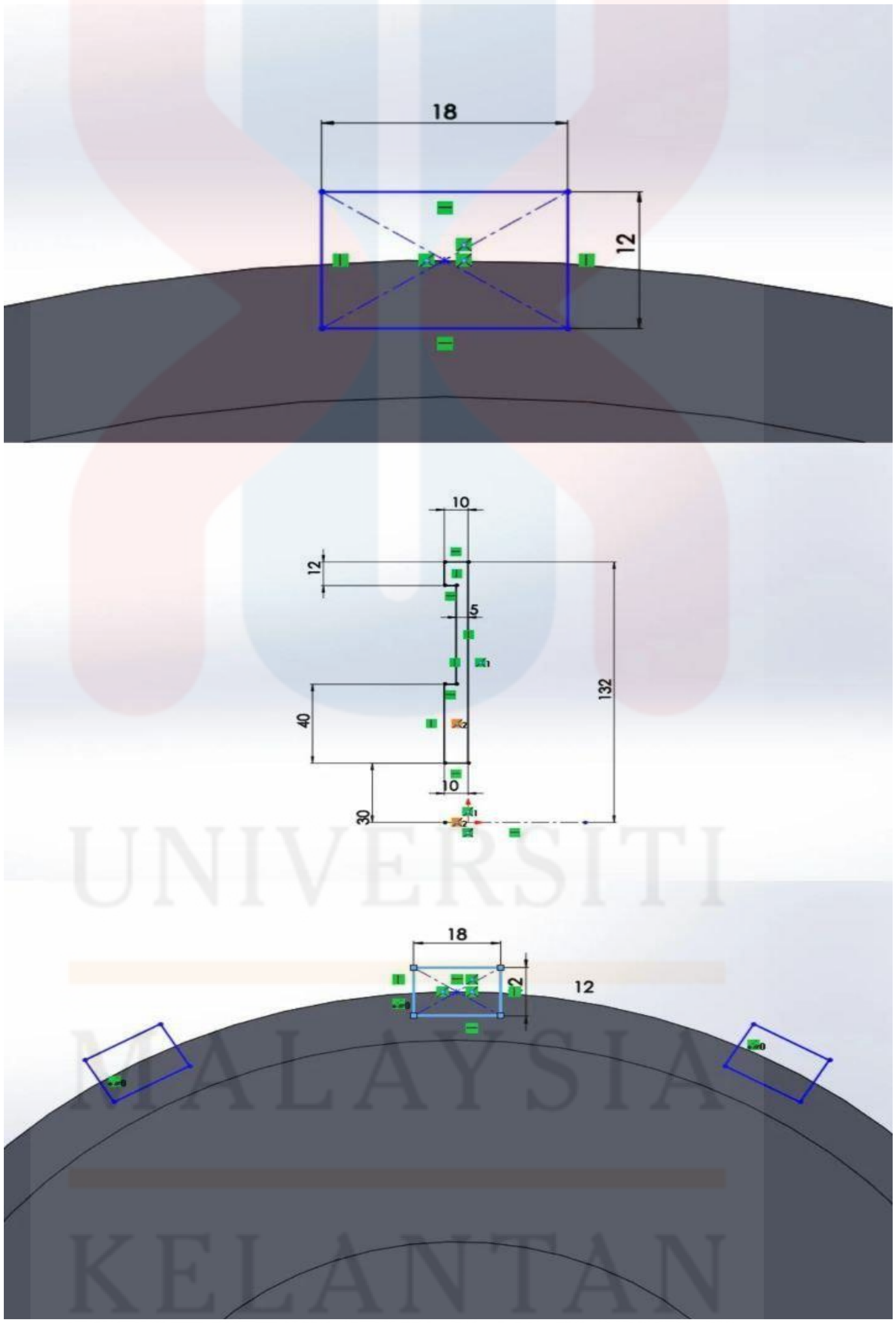

Figure 3.1: 2D Sketching of Flywheel Thresher Machine

Figure 3.2: Final Design of Flywheel in Thresher Machine

CHAPTER 4: RESULT AND DISCUSSION

4.1 Reaction Load and Fixture

There are three different materials that have been used to excite the flywheel of the thresher machine. Materials such as grey cast iron, 4340 alloy steel, and AISI/SAE 1055 Carbon Steel have been used in the construction of the flywheel thresher machine. These materials are utilized for the application of loads and fixtures. The loads and fixtures that were associated with the flywheel thresher machine during the simulation are detailed in Table 4.1.

Table 4. 1: The loads and fixture of the flywheel for the thresher machine for different Materials.

Materials	Reaction Force (X-Component)	Reaction Force (Y-Component)	Reaction Force (Z-Component)	Resultant Force
Gray Cast Iron	-0.00026906	-0.00031662	9.4324 X 10^-6	0.00041561
4340 Alloy Steel	-0.00012469	6.485 X 10^-5	-7.5996 X 10^-6	0.00014075
AISI/SAE 1055 Carbon Steel	-0.00029635	-9.7275 X 10^-5	5.9158 X 10^-6	0.00031197

As part of this simulation, a torque force of 550 Newtons was applied to the upper surfaces of the flywheel thresher machine's teeth. While picture 4.1 illustrates the load that is being given to the teeth of the flywheel thresher machines, figure 4.2 illustrates the fixture that is used for flywheel thresher machines.

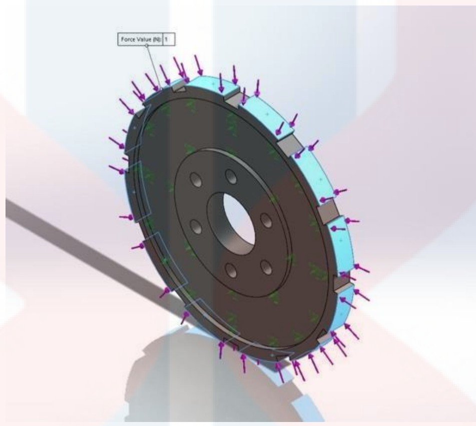

Figure 4.1: Load applied on the Flywheel Thresher Machines

Figure 4.2: Fixed Geometry applied on the Flywheel Thresher Machines

4.2 Materials Result

For this chapter, the results of simulation will be presented then each materials result will be compared. Then material from these studies will be compared with each other in terms of stress, strain and displacement for the maximum value and the low value for each materials data.

4.3 Analysis of stress, strain, and displacement for alternative material

First, SolidWorks simulations are used for both design and analyze stress analysis, strain analysis and displacement analysis. Figure 4.2 represents stress, strain, and displacement analysis of Glass Fiber Type -S.

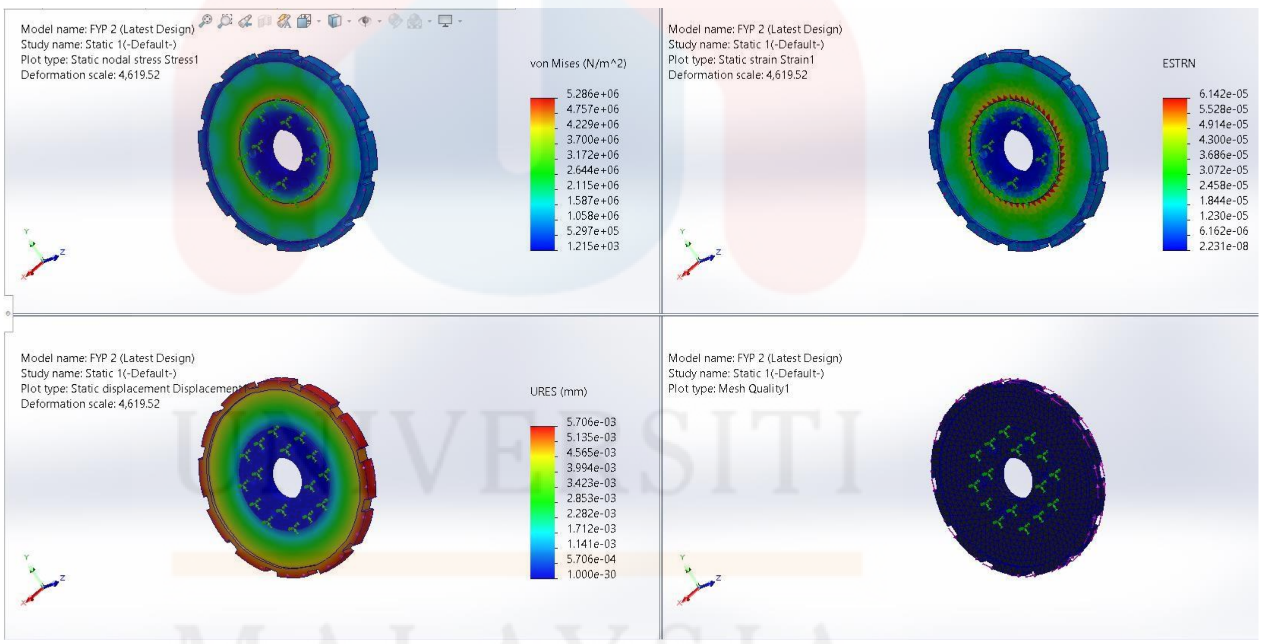

Figure 4.3: The Stress, Strain and Displacement result of Glass Fiber Type -S

Glass Fiber Type -S is the alternative material that has been suggested for the flywheel in the thresher machine instead of Cast Iron. The stress, strain, and displacement that occur from this material are shown in the figure that is located above. These examinations are shown in the figure that may be seen above. During the process of applying the material to the flywheel, the graphic illustrates the highest and lowest stresses, as well as the strain and displacement of the material. Based on the stress plot, the maximum amount that can be acquired is 5.293e+06 N/m2, while the minimum amount that can be obtained is 1.464e+03 N/m2. When it comes to the test strain, the highest possible quantity is 4.449e-05, while the lowest possible amount is 1.590e-08. There is a range of potential values for displacement, with the maximum possible value being 4.133e-03 mm and the lowest possible value being 1.000e-30 mm.

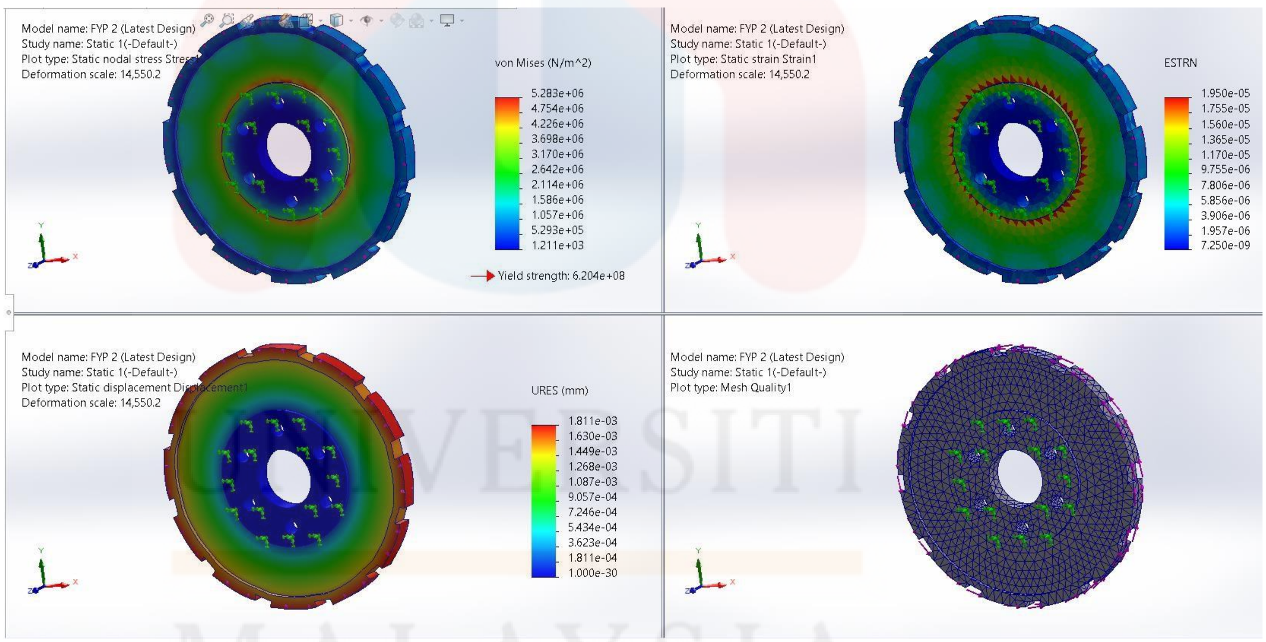

Figure 4.4: The Stress, Strain and Displacement results of 4340 Alloy Steel

When it comes to the Flywheel for the Thresher Machine, the maximum stress plot is 5.283e+06 N/m2, while the lowest stress plot is 1.211e+03 N/m2. While the greatest possible value for strain is 1.950e-05, the lowest possible value is 7.250e-09, and the highest possible value is 1.950e-05. When it comes to displacement, the maximum value that can be attained is 1.811e-03 mm, and the lowest value that can be achieved is 1.000e-30 mm. Both positions are possible.

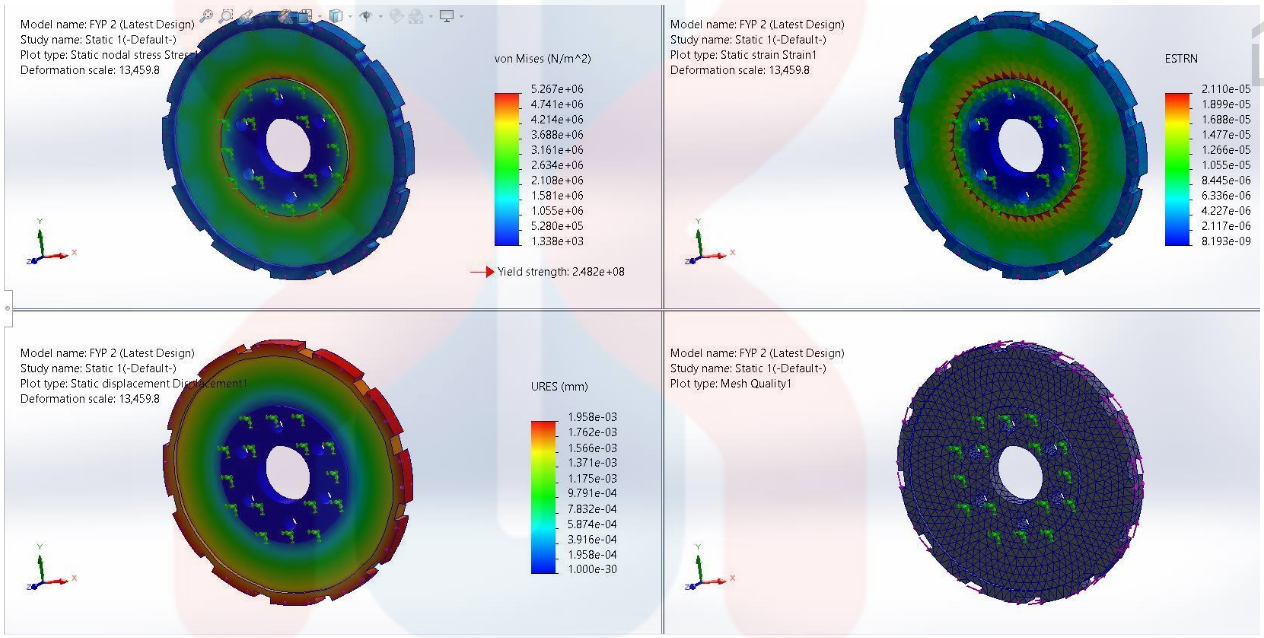

Figure 4.5: The Stress, Strain and Displacement results of AISI/SAE 1055 Carbon Steel

If we look at the stress plot for AISI/SAE 1055 Carbon Steel, we can see that the highest possible value is 5.267e+06 N/m2, while the lowest possible value is 1.338e+03 N/m2. There is a range of potential values for strain, with the greatest possible value being 2.110e-05 and the lowest possible value being 8.193e-09. One thousand thirty millimeters is the absolute lowest value for displacement, while one thousand five hundred and eighty-three millimeters is the absolute highest value for displacement.

4.4 Materials Comparisons

When the materials from the research have been studied, it is demonstrated that the glass fiber type -S is considered acceptable as an alternative material for flywheel thresher machine design. This is since there is a slight difference in terms of material attributes between the glass fiber type -S and Cast Iron. Comparative analysis of the materials used in this research is shown in Table 4.2. In addition, the other two materials that were investigated in this research will also be compared to the real materials that are used in the production of flywheels for thresher machines.

Table 4.2: A comparison between Cast Iron and Glass Fiber Type -S in terms of stress, strain, and displacement.

Result	Cast Iron	Glass Fiber Type -S	Unit
Stress	5.286e+06	5.293e+06	N/m^2
Strain	6.142e-05	4.449e-05	*N/A*
Displacement	5.706e-03	4.133e-03	Mm

In this study, it shows the comparisons between cast iron and glass fiber type -S in terms of stress, strain, and displacement. For the Stress data, the glass fiber type- S are slightly better than the cast iron with the value data of 5.293e+06 N/m^2 for the glass fiber type -S and 5.286e+06 N/m^2 for the cast iron. Unfortunately, the value data for strain is a bit low for the glass fiber type -S at 4.449e-05 compared to the cast iron value data strain at 6.142e-05. But the value data displacement for glass fiber type -S at 4.133e-03 mm which is slightly low compared to the cast iron displacement value data at 5.706e-03 mm.

Table 4.3: A comparison between Cast Iron and 4340 Alloy Steel in terms of stress, strain, and displacement.

Result	**Cast Iron**	**4340 Alloy Steel**	**Unit**
Stress	5.286e+06	5.288e+06	N/m^2
Strain	6.142e-05	1.950e-05	*N/A*
Displacement	5.706e-03	1.811e-03	Mm

For both materials, we can clearly see that the 4340 alloy steel materials are better in terms of stress and displacement but lower at strain compared to the cast iron material. It is recorded that the value data stress and displacement for 4340 alloy steel at 5.288e+06 N/m^2 and 1.811e-03 mm while for the cast iron, the value data for stress and displacement recorded at 5.286e+06 N/m^2 and 5.706e-03 mm. For the value data for strain, 4340 alloy steel is very low compared to the cast iron with value data at 1.950e-05 for 4340 alloy steel and 6.142e-05 for cast iron.

Table 4.4: A comparison between Cast Iron and AISI/SAE 1055 Carbon Steel in terms of stress, strain, and displacement.

Result	Cast Iron	AISI/SAE 1055 Carbon Steel	Unit
Stress	5.286e+06	5.267e+06	N/m^2
Strain	6.142e-05	2.110e-05	*N/A*
Displacement	5.706e-03	1.958e-03	Mm

Same as the materials before, the AISI/SAE 1055 Carbon Steel also can be a good alternative as flywheel thresher machine material to replace Cast Iron. We can look at the table above which shows the value data for stress for both materials that are not many differences. 5.267e+06 N/m^2 value data for the AISI/SAE 1055 Carbon Steel and 5.286e+06 N/m^2 value data for Cast Iron. Even though the value data strain for AISI/SAE 1055 Carbon Steel are very low compared to the Cast Iron value data, the displacement value data for AISI/SAE 1055 Carbon Steel are much greater compared to the Cast Iron displacement value data at 1.958e-03 mm for the AISI/SAE 1055 Carbon Steel and 5.706e-03 mm value data for Cast Iron.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

In conclusion, the stress distribution, strain, and displacement of the selected material were studied. This has been achieved by doing an analysis and comparison of the original material, which was Cast Iron, with the three materials that were proposed, which were Glass Fiber Types -S, 4340 Alloy Steel, and AISI/SAE 1055 Carbon Steel. For the objective of determining which material is the most suitable, particularly as a substitute for the material that was first used in the production of flywheels for thresher machines, a significant amount of data and information has been obtained.

So, in this study, the objective has been achieved which is to define the mechanical properties for each suggested material and to make a comparison of cast iron replacement materials. When comparing the actual material for the flywheel in the thresher machines, which is cast iron with all the suggested materials which is Glass Fiber Types -S, 4340 Alloy Steel, and AISI/SAE 1055 Carbon Steel, mostly the suggested materials have a better mechanical property in terms of stress and displacement even though slightly low in strain.

To justify, all the three alternative materials are suitable to replace the cast iron as a main material for flywheel in thresher machine production. This is because all the three alternative materials have high value data in stress and low value data in displacement even though a bit low in strain, but it is still recommended to replace the cast iron since using it as a main material for flywheel thresher machines can lead to centrifugal loading and low deformation problems. Thus, I can personally confirm that all the alternative materials are suitable for replacement cast iron as a main material for flywheel in thresher machines.

5.2 Recommendations

The primary goal of this research was to define the mechanical properties and make a comparison among the alternative materials in the production of flywheel for thresher machine. However, here are a few recommendations that can be implemented to improve the material selection and product quality. So, in this study, what I can recommend is to consider first the material properties before producing the flywheel. The density, strength, stiffness, fatigue resistance, thermal conductivity, and magnetic permeability of the material are some of the attributes that should be considered. These characteristics may be found in a variety of different combinations depending on the material.

Next, for example, as we know that flywheel is an important part of machine for the accumulation and storage of rotational energy to produce power source, ensuring efficient power transmission to the machine to keep working. So, what we need is that the materials should have strength, stiffness, density, thermal characteristics, and fatigue resistance. Thus, the important thing is the material selection. A shortlist of materials that satisfy the relevant criteria should be created based on the operational needs and the findings of the characterization evaluation. Materials like steel, aluminum, carbon fiber composites, and sophisticated ceramics are often used for the construction of flywheels.

Last but not least, my recommendations for future research may be about optimization for the material. In a case that it is required, iterate the process of designing and selecting the materials to maximize the effectiveness of the flywheel for the application. Also, for the performance evaluation, using simulations or prototypes, evaluate the performance of each of the available material options. There are a few considerations to consider, including the cost, weight, and manufacturability of the product.

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