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Design & Optimization of Flywheel in Thresher Machine

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Abstract – *In order to improve the performance of the multi-crop Haawa Dhawa thresher machine, this study focuses on optimizing the flywheel design. The Haawa Dhawa thresher machine is a particular piece of agricultural equipment used for processing different types of crops. In order to increase the Haawa Dhawa thresher machine's total productivity and efficiency, the research investigates the optimization of the flywheel component.*

Building a CAD model of the Haawa Dhawa thresher and performing a flywheel-focused finite element analysis (FEA) are both steps in the optimization process. The optimization approach includes design modifications, material selection, and performance evaluation as core components. To lessen the total weight of the Haawa Dhawa thresher machine, mass optimization of the flywheel is also prioritized in addition to energy transfer efficiency.

The research's findings aid in the creation of more effective and productive agricultural equipment, particularly the multi-crop threshing machine Haawa Dhawa. The Haawa Dhawa thresher machine performs noticeably better because to flywheel optimization. Additionally, the flywheel's mass optimization results in a lighter Haawa Dhawa thresher machine, making it easier to transport and operate. These improvements in the Haawa Dhawa thresher machine's optimization lead to increased productivity and efficiency in crop processing operations for a variety of crops

Keywords*-Thresher, Flywheel, Haawa Dhaba, Optimization, FEM, CAD.*

INTRODUCTION

Modern farming is much more productive now that crop processing methods have been revolutionized by agricultural machinery. Threshers are one of these tools that have been essential in effectively separating grains from harvested crops, producing clean, market-ready grains. Due to its adaptability, durability, and affordability, the Haawa Dhawa thresher machine has grown in favor in the agricultural industry, especially among small- to medium-sized farmers. However, there is always potential for advancement in terms of enhancing its capacity for crop processing and increasing performance and efficiency. Traditional thresher machines have significantly improved over time, adopting innovations including power transmission methods, better material selection, and more effective component designs. These developments have increased production and decreased the need for labor. Even yet, there are still issues with optimizing thresher machines to maximize efficiency, reduce crop losses, and boost throughput.

The flywheel, one important part of a thresher machine, is essential for storing and releasing kinetic energy to maintain circular motion throughout the threshing operation. The machine can manage fluctuations in load and maintain a constant speed thanks to the flywheel's function as an energy storage device. The efficiency of energy transfer, the consistency of operation, and the overall effectiveness of the thresher machine can all be significantly improved by modifying the flywheel's design and properties. This study intends to investigate the Haawa Dhawa thresher machine's flywheel design optimization in this setting. The research intends to improve the machine's performance, boost energy transfer effectiveness, and ultimately boost agricultural processing productivity by concentrating on the flywheel component. The study will look into a variety of factors of flywheel optimization, including material choice, design modifications, and mass optimization. The research will help design agricultural equipment that is more productive and efficient, which will be advantageous to farmers and the agricultural sector.

An extensively used agricultural tool created specifically for effective crop threshing is the Prakash Haawa Daba 3 Fan thresher. It has become a well-liked option in the agricultural market thanks to its adaptable design and functional qualities. The Prakash Haawa Daba thresher's design and specifications are covered in detail in this introductory part, which also highlights the threshing mechanism, output capacity, power demand, and construction material.

The Prakash Haawa Daba thresher is designed to run at speeds between 500 and 1000 RPM, providing best performance and crop variety adaptability. Three blades on the device enable efficient threshing and guarantee the separation of grains from the harvested crops. The Prakash Haawa Daba thresher exhibits excellent characteristics in terms of production capacity, with a range of 2001 to 3000 kg/hr. Because of this, it works well for medium-sized threshing operations and gives farmers effective processing capabilities.

The Prakash Haawa Daba thresher requires a mechanical power input of 20 to 40 HP to power its components. This power demand assures that the machine will run efficiently, enabling constant and dependable performance throughout threshing.

The Prakash Haawa Daba thresher's body is made of MS (Mild Steel) during construction. MS is a material well-known for its sturdiness and dependability that is incredibly long-lasting and corrosion resistant. The thresher can survive the harsh conditions of agricultural activities because of the use of MS, which guarantees the thresher's durability.

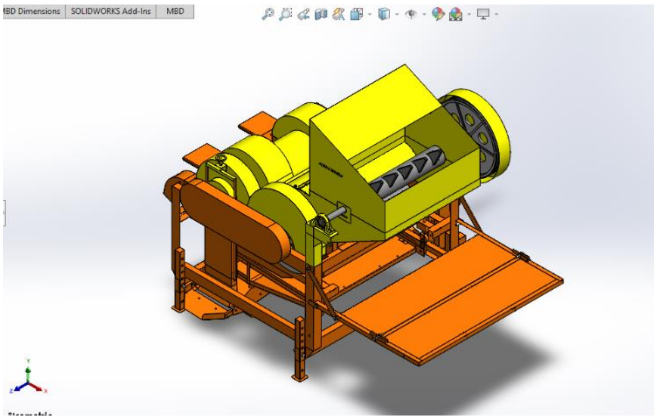
The Prakash Haawa Daba 3 Fan thresher offers a high output capacity, a well-designed frame, an effective threshing mechanism, and sturdy building materials. These characteristics make it a significant asset for farmers operating medium-scale threshing operations, giving them access to a dependable and effective grain processing solution. To further improve the performance and output of the thresher, we will examine the flywheel design optimization in the sections that follow..

METHOLOGY

A thorough CAD (Computer-Aided Design) model is required to start the Prakash Haawa Daba 3 Fan thresher machine's optimization process. The building of a current, complete CAD model of the thresher machine, which is extensively used in the agricultural sector for threshing various crops, is the main topic of this part. The entire machine, including its essential pieces like the flywheel, threshing drum, and other pertinent sections, is shown in the CAD model. The creation of a precise digital depiction of the Prakash Haawa Daba thresher machine is the main goal of this section. To provide a realistic simulation of the machine's behavior during the optimization process, this requires recording the design requirements, dimensions, and material properties of the machine.

Fig. 1: CAD Model of Haawa Dhaba Thresher

Engineers and academics can examine and assess the functionality, performance, and structural integrity of the thresher machine using the CAD model as a virtual prototype. The CAD model offers a thorough platform for carrying out numerous studies and comparisons since it includes the complex features of the flywheel, threshing drum, and other components. This section, in particular, emphasises the investigation of both the current and potential new designs for the Prakash Haawa Daba thresher machine's flywheel. Advanced analysis methods, such as finite element analysis (FEA), can be used to evaluate the behaviour of the flywheel under various loads, rotating speeds, and material characteristics.



DESIGN

There are two flywheels present in thresher machine, As with output of 2000 to 3000 kg/hour, with one large flywheel lot of there will be lot of vibrations. The existing flywheel is section cut flywheel and the new design flywheel is a 6-spoke flywheel. While attempting to design new flywheel various flywheels were taken into consideration and tried performing analysis on them under the 1000 RPM of rotational velocity. We even tried different types of section cut existing old flywheel and perform analysis. Through trial and error 6-spoke flywheel was selected, which in turn reduced mass of flywheel as well as improved performances which we will see further. Following are dimensions with drafting.

Fig. 2: CAD Model of Haawa Dhaba thresher without cover

Fig. 3: Old Flywheel (existing) Drafting

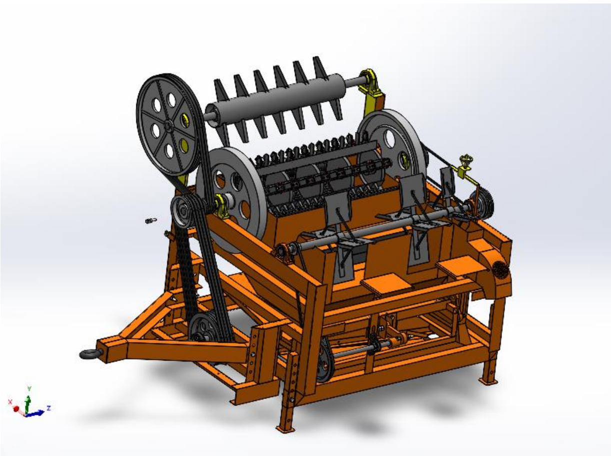
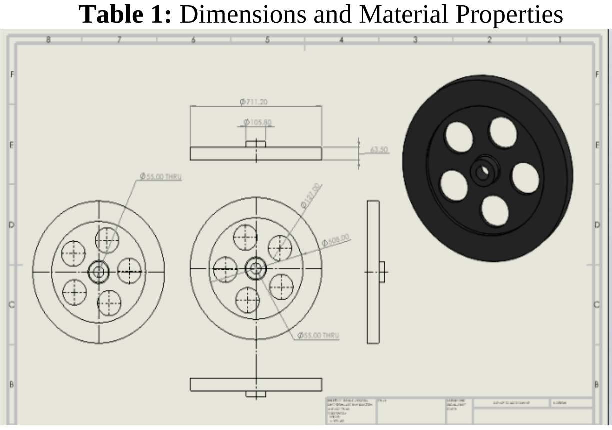
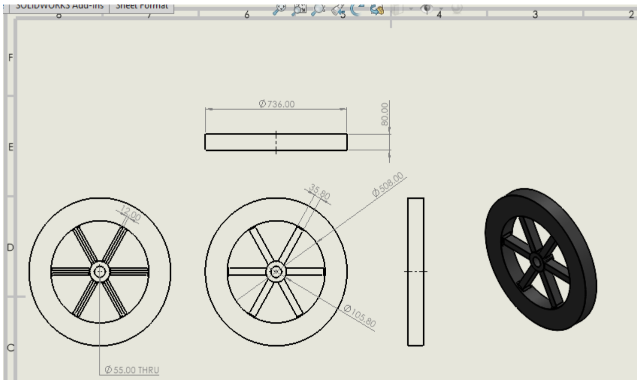


Fig. 4: New Flywheel Drafting

Table 1: Dimensions and Material Properties





Dimensions	Old Flywheel	New Flywheel
Outer Disk	711.20 mm	736 mm
Inner disk	508 mm	508 mm
Outer Hub	105.80 mm	105.80 mm
Inner Hub	55 mm	55 mm
Section Cut	5 circular cut of 127 mm	6 spoke of 35.80 mm (rectangular Slot of 11.80 mm)
Material	Cast Iron	Cast Iron
Density	7510 kg/m3	7510 kg/m3

CALCULATIONS

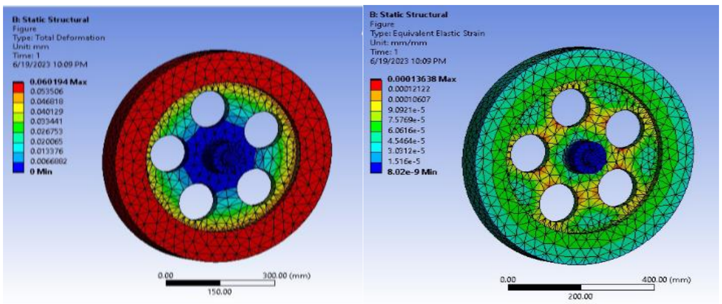
Table 2: Calculations for Old and New Flywheel

Parameters	Formulae	Old Flywheel	New Flywheel
Angular velocity (ω)	ω = (2 × π × N) / 60	104.72 rad/sec	104.72 rad/sec
Surface speed (Vs)	Vs = (π × D × N) / 60	37.33 m/s	38.68 m/s
Energy stored in the flywheel	Ek = 0.5 × Itotal × ω^2	32,031.54 J or 32.03 KJ	35,052.22 J or 35.05 KJ
Specific energy	Ek,m = Ek / Mtotal	0.4392 KJ/kg	0.4900 KJ/kg
Energy Density	Ek,v = (Ek / Mtotal) × ρ	3301.27 KJ/m^3	3673.59 KJ/m^3

ANALYSIS

On flywheel we performed static structural analysis with inertia of 1000 RPM. And find out Total deformation, equivalent strain, von mises stresses and FOS. And at the end we compare results of both flywheels.

Old Flywheel Results:



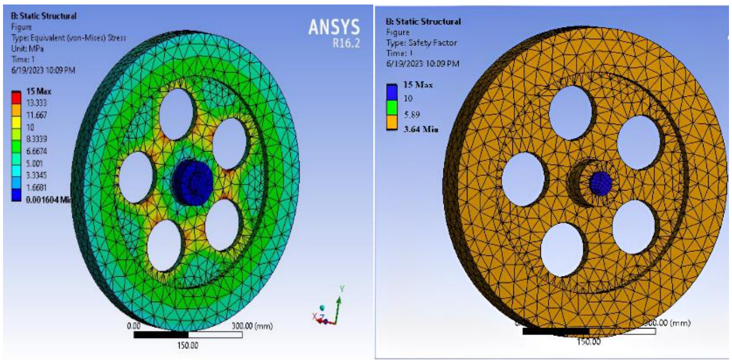


Fig. 5: Analysis on Old Flywheel

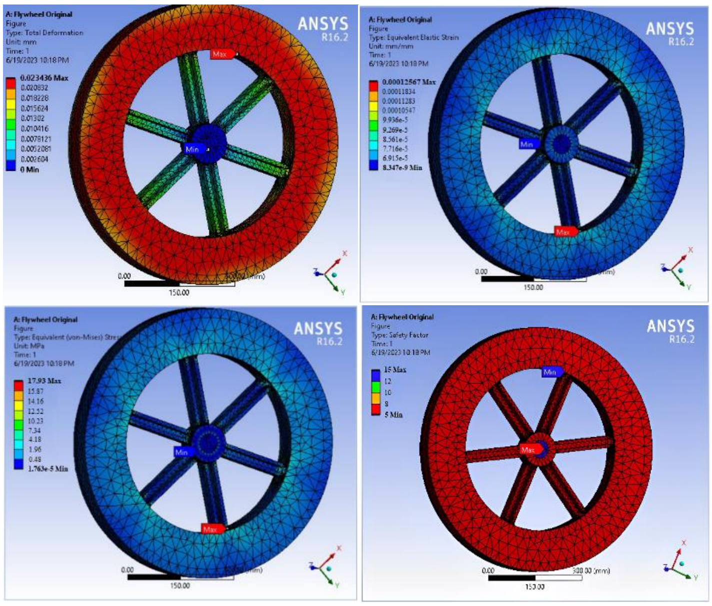


Fig. 6: Analysis on New Flywheel

Table 3: Result Comparison of Old and New Flywheel

Parameters	Old Flywheel	New Flywheel
Total Deformation	0 to 0.060194 mm	0 to 0.023436 mm
Equivalent Elastic Strain	8.02e-9 to 0.00013638	8.347e-9 to 0.00012567
Von Mises Stress	0.001604 to 15 Mpa	1.763e-5 to 17.93 Mpa
FOS	3.64 to 15	5 to 15

RESULT AND DISCUSSION

The flywheel analysis and optimization provided valuable insights into the performance of the existing and new flywheel designs. The following observations were made:

1. Total Deformation: The new flywheel demonstrated a lower maximum deformation (0.023436 mm) compared to the existing old flywheel (0.060194 mm). This indicates that the new design exhibits improved structural rigidity and is less prone to deformation under applied loads.
2. Equivalent Elastic Strain: The new flywheel demonstrated a slightly lower elastic strain (0.00012567) compared to the existing old flywheel (0.00013638). This also indicates that the new design exhibits improved structural rigidity and is less prone to deformation under applied loads.
3. Von-Mises Stress: The new flywheel exhibited a higher maximum von-Mises stress (17.93 MPa) compared to the existing old flywheel (15 MPa). This suggests that certain regions of the new flywheel may experience higher stress concentrations. Even though the value of maximum stress is little bit higher than existing flywheel, they are within limit.
4. Factor of Safety (FOS): The new flywheel demonstrated a factor of safety ranging from 5 to 15. And the old flywheel demonstrated FOS from 3.64 to 15. This indicates that the new design has an acceptable safety margin and can withstand the applied loads without experiencing failure.
5. If we replace both old flywheel with new flywheel in thresher machine, according to above calculation these are improvement we will get to see.

Parameters	Old Flywheel	New Flywheel	Impact of replacing both flywheel in machine
Mass (m)	73 Kg	71.44 Kg	-3.12 Kg (Less Mass)
Angular velocity (ω)	104.72 rad/sec	104.72 rad/sec	0 rad/sec
Surface speed (Vs)	37.33 m/s	38.68 m/s	2.7 m/s
Energy stored in the flywheel	32,031.54 J or 32.03 KJ	35,052.22 J or 35.05 KJ	6.04 KJ
Specific energy	0.4392 KJ/kg	0.4900 KJ/kg	0.1016 KJ/Kg
Energy Density	3301.27 KJ/m^3	3673.59 KJ/m^3	744.64 KJ/m^3

CONCLUSION

In conclusion, the flywheel designs' study and optimization yielded useful information about their performance. Comparing the new flywheel design to the old flywheel, the new flywheel showed enhanced structural rigidity with lower maximum deformation and elastic strain. The maximum von-Mises stress of the new flywheel was slightly higher, but it was still within acceptable bounds. The new flywheel's factor of safety revealed a respectable safety margin, assuring its capacity to endure applied loads without failing.

The thresher machine would benefit from replacing both of its old flywheels with the new flywheel design in the following ways:

1. Mass: The new flywheel is lighter than the old flywheel by 1.56 kg, making total thresher weighing 3.12 kg less.
2. Angular velocity: The angular velocity of the new and old flywheels is 104.72 rad/sec.
3. Surface speed: The new flywheel's surface speed is 1.35 m/s faster than the old flywheel's, which had a surface speed of 37.33 m/s.
4. Flywheel energy storage: The new flywheel has an increased energy storage capacity of 3.02 KJ over the old flywheel, contributing a total of 6.04 KJ excessive energy .
5. Energy transfer efficiency has improved, as seen by the new flywheel's greater specific energy of 0.4900 KJ/kg compared to the old flywheel's 0.4392 KJ/kg.
6. Greater energy storage per unit volume is made possible by the new flywheel's higher energy density, which is 3673.59 KJ/m3 compared to the old flywheel's 3301.27 KJ/m3.

Overall, the performance and efficiency of the thresher machine would be improved by swapping out both of the outdated flywheels with the new flywheel design. These gains would be made in mass reduction, energy storage capability, energy transfer efficiency, and energy density.

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