DESIGN AND FABRICATION OF HPFM CHAFF CUTTER MACHINE

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Abstract—: Chaff cutting is a crucial agricultural practice that involves the reduction of straw or fodder into smaller, more manageable pieces to improve livestock feed efficiency. The need for efficient and cost-effective chaff cutting machinery has grown significantly in the modern agricultural landscape. This research paper presents the design and fabrication of a High-Performance Forage Material (HPFM) chaff cutter machine, aimed at enhancing the chaff cutting process in a sustainable and productive manner. The study begins with a comprehensive review of existing chaff cutter designs, highlighting their limitations and potential areas for improvement. Subsequently, the research focuses on the innovative design of the HPFM chaff cutter machine, which incorporates advanced features such as high-speed cutting blades, adjustable cutting lengths, and increased safety mechanisms. The design process involves 3D modeling and simulation to ensure the machine's performance and safety. Following the design phase, the fabrication of the HPFM chaff cutter machine is detailed, including material selection and manufacturing techniques. The machine's components are carefully assembled, and quality control measures are implemented to ensure durability, efficiency, and ease of maintenance. The performance evaluation of the HPFM chaff cutter machine is carried out through comprehensive testing, comparing its cutting efficiency, energy consumption, and operational safety with traditional chaff cutters. The results indicate a significant improvement in cutting efficiency and a reduction in energy consumption, making the HPFM chaff cutter a more sustainable and cost-effective choice for farmers.

Keywords - Chaff cutter, High-Performance Forage Material (HPFM), Agriculture, Livestock feed, Cutting efficiency, Energy consumption, Farm machinery, Innovation, 3D modeling

1. INTRODUCTION

The field of agriculture has been a driving force behind human progress for millennia, providing sustenance, raw materials, and livelihoods to communities around the world. In the pursuit of increased agricultural efficiency and sustainability, the management of agricultural waste has emerged as a critical concern. One such waste product is chaff, primarily consisting of straw and hay, which poses unique challenges in waste management. The High-Performance Chaff Cutter Machine (HPFM) represents a significant technological innovation designed to transform the way agricultural waste, particularly chaff, is processed and managed.

The HPFM Chaff Cutter Machine is a cutting-edge piece of agricultural equipment engineered to efficiently reduce chaff into smaller, more manageable pieces. This device stands as a testament to the ongoing progress in agricultural machinery, integrating modern engineering and fabrication techniques to enhance agricultural productivity and sustainability.

This introduction sets the stage for a comprehensive research paper by providing an overview of the HPFM Chaff Cutter Machine, its importance in agricultural waste management, and the potential implications for the broader agricultural industry. It offers a glimpse into the technological innovations driving the HPFM's design and fabrication, as well as the transformative impact it has on modern farming practices.

Background and Significance

Agriculture is a dynamic field that has constantly adapted to meet the changing demands of growing populations and the challenges of sustainability. In this pursuit, efficient waste management in agriculture, including the handling of byproducts like chaff, has often been overlooked. Chaff, primarily comprising straw and hay, is generally regarded as agricultural waste that is either discarded or repurposed as livestock feed. Nevertheless, the effective management of chaff is integral to modern agriculture, as it can significantly influence soil health, crop quality, and overall farm productivity.

Traditional methods of chaff management were labor-intensive and time-consuming, often involving manual chopping or even burning of excess straw and hay. These methods not only proved inefficient but also environmentally unfriendly, leading to the emission of harmful pollutants and the wastage of valuable organic material. It was evident that a more sustainable and efficient solution was necessary.

FIG: 1 HPFM Chaff Cutter Machine

Objective of the Study

The primary aim is to enhance the design and functionality of the chaff cutter machine to make it more efficient, cost-effective, and safer. This includes improving cutting efficiency, prioritizing safety measures, and ensuring affordability for small-scale farmers. Additionally, user-friendliness, durable materials, energy efficiency, and innovation are key considerations in the project. These objectives collectively seek to empower farmers with a more productive and reliable tool for fodder cutting, ultimately contributing to agricultural progress.

2. LITERATURE REVIEW

Johansen et. al conducted a study on the modernization of farming equipment. They highlighted the increasing global demand for beef, meat, and dairy products, which has prompted the need to boost production. Small-scale farmers worldwide face a significant challenge in obtaining high-quality fodder for their livestock, particularly during the winter season. Fodder maize and rice straw are the primary sources of livestock feed, but their quality is often compromised. Consequently, the central issue revolves around providing farmers with superior fodder quality. In addition, manually cutting fodder is not only labor-intensive but also time-consuming. Consequently, farmers often resort to feeding their livestock with whole fresh or dried leaves and stems, resulting in considerable fodder wastage, with 15% to 20% being rejected by the animals. To mitigate this wastage and address these challenges, the Power Straw and Fodder Chopper (PSFC) was developed. However, it should be noted that this machine, while effective at chopping fodder, has certain safety shortcomings, leading to injuries such as cuts on arms, hands, and fingers. To meet the demands of the modern era and enhance farmer safety, there is a compelling need for the development of a modified fodder chopper that is not only easily accessible but also affordable. This would serve to alleviate the issues associated with fodder quality and reduce the risk of injuries during the chopping process.

Khope and colleagues (2013) et. al conducted a study focusing on the intricate design of experiments required to establish an empirical relationship concerning the process of chaff cutting, driven by a human-powered flywheel motor. The authors delved into various aspects, including the identification of variables, dimensional analysis, the definition of the test parameters, test points, sequencing for independent π terms, instrumentation and measurement techniques, procedures for data verification and rejection, and the methodology for data analysis. Their detailed experimental design encompassed a thorough dimensional analysis of the system, the determination of the test parameters, sequencing of test points for the independent π terms, methods for instrumentation and measurement, strategies for checking and eliminating erroneous data, and the approach to analyze the collected data. One noteworthy aspect addressed in the study is the relationship between flywheel speed and the kinetic energy stored in the flywheel. To enhance the flywheel's speed, a bicycle mechanism with a speed-rising gear pair was employed. This system effectively reduces the effort required by the operator to accelerate the flywheel. The gear pair maintains a constant ratio of 1:5, ensuring minimal process resistance during the flywheel acceleration. While the flywheel speed can be increased up to 700-800 rpm, it's essential to note that such high speeds can lead to excessive vibrations that might affect the accuracy of the sensors used to measure various variables. As a result, the testing sequence typically progresses from minimum to maximum speeds, ranging from 300 to 600 rpm, with gear ratios varying from 2:1 to 4:1 to amplify torque, while considering the number of blades, which can be either 2 or 3. This carefully selected testing sequence is apt for establishing an empirical relationship regarding the chaff cutting process when energized by human power.

Zakiuddin et. al In their 2010 study, explored the use of a pedal-operated flywheel motor as an energy source for a fodder chopper. The researchers underscored the pressing energy challenges experienced by developing nations and identified the pedal-operated flywheel motor as a practical solution. This machine not only proves to be eco-friendly but also plays a significant role in conserving power resources. The study's core conclusion emphasized the adoption of non-conventional energy sources to power fodder chopper machines. This innovation not only holds the potential to enhance fodder processing but also creates employment opportunities for unskilled individuals, both men and women. The system operates by utilizing a flywheel as a power source, with human power driving the flywheel. Remarkably, the flywheel attains a speed of 600 revolutions per minute, showcasing its effectiveness in this regard. The pedal-operated flywheel motor is a carefully designed and fabricated apparatus, comprising essential components such as the flywheel, chaff cutter, shaft, clutch, and gear. Its performance primarily relies on human effort, making it a feasible and sustainable energy solution for powering fodder choppers, particularly in regions facing energy scarcity.

Mohan et. al (2014) explored the process of conducting a community-based investigation and the incorporation of safety enhancements in the design of fodder cutting machines. They highlighted the prevalent issue of severe hand injuries affecting both adults and children in rural areas due to these machines. These injuries typically fell into two categories: accidents involving adults occurred during feeding, due to loose clothing or when hands came into contact with the blade during maintenance or sharpening.

To address these safety concerns, various innovations were introduced to make fodder cutters safer. These innovations included a warning roller, typically constructed from metal or wood, placed in front of the feed roller to serve as an alert mechanism, notifying the operator if their hand ventured into a dangerous zone. Additionally, a blade safety guard, comprising a mild steel rod with a 9mm diameter, was mounted on the fodder cutter. This guard not only pushed limbs away but also acted as a warning signal.

To further enhance safety, a gear cover made from mild steel sheet was introduced to shield the open gear, minimizing the risk of accidents. A flywheel locking pin, connected via a chain, was implemented to immobilize the fodder cutter's flywheel when not in use. Finally, local technicians began incorporating finger guards during the manufacturing process of existing machines to bolster safety measures and protect operators from potential harm.

Bandiwadekar et. al In their 2016 research, and their team delved into the planning and development of a debris-cutting machine. The authors introduced a novel cutting apparatus that not only enhances safety but also reduces effort, all while minimizing power consumption. This innovative machine is specifically tailored for small-scale farmers who need to regularly feed their cattle on a small to medium scale. Thanks to the utilization of advanced cutting technology, this machine experiences significantly less wear and tear on its blades compared to conventional machines, which require frequent blade sharpening. Furthermore, when mass-produced, this machine is expected to be more cost-effective, offering an economical solution for farmers.

Ahmad et. al (2015) conducted a study examining the removal of fodder cutter injuries and assessing the associated risk factors. The aim of their research was to determine the extent of injuries caused by "toka" machines and to identify the gender more susceptible to these injuries, specifically in southern Punjab. The authors noted that traumatic fodder cutter injuries are severe and uncommon. They affect individuals across different social classes, including children who are also victims of such accidents. These incidents often occur when children are left unsupervised at home while their parents are busy with farmyard activities. The study encompassed 73 patients who had been affected by power-driven "toka" machines, with 32 being male and 41 female. The authors emphasized that prevention is the key, and it can be achieved through proper operator training and the appropriate design of fodder cutter machines. In the manufacturing of these machines, safety should be a priority, and they should meet specific safety criteria, including the incorporation of safety features such as separate gears, conveyor belts, cutoff detectors, emergency brakes, enhanced rollers, chemical sensors, automatic switching, and retractable rollers.

Singh et. al (1997) conducted a study aimed at improving the design of a fodder cutter. They sought to create a more efficient machine compared to existing models. In traditional machines, grain must be fed in small batches, and great care must be taken to ensure the quantity is neither too much nor too little. If overfed, the machine is unable to handle the excess grain, releasing it as is. This often requires manual pushing of the straw into the machine, which can pose a risk of hand injuries. In the modified machine, grain bags are simply placed on the feeding chute, eliminating the need for manual feeding and making the operation safer. Existing machines require blade sharpening after a period of use. In contrast, the new machine features serrated blades, eliminating the need for sharpening. When the teeth wear out, new ones can be cut into the blades. The current machine has limited capacity and consumes a substantial amount of power. However, the proposed machine has the potential for higher capacity and lower power consumption. It incorporates an inclined feeding trough for the straw, enabling automated feeding and reducing the need for labor.

Anant J. Ghadi et al This paper explores diverse corn de-husking methods. Historically, the Aztecs and Mayans developed techniques to cook and grind corn, which was cultivated in various varieties across central and southern Mexico. In the agricultural industry, the prevailing corn de-husking methods involved manual labor or the use of large, costly machinery for deseeding. These methods prove ineffective in developing economies like India, where farmers have limited resources for investment. Hence, there is a pressing need for innovative, cost-effective, and safe solutions to enhance productivity for Indian farmers.

Anirudha G. Darudkar et al This paper addresses the significant challenge in corn production, which is the lack of efficient corn processing machines, especially corn shellers. In essence, this paper outlines the design of various components of a corn sheller machine. It entails the consideration of forces and ergonomic factors to create a new, power-operated corn shelling machine with a simple mechanism that can be easily transported and operated anywhere. The project aims to introduce an innovative concept in machine design to enhance corn threshing efficiency.

J.N. Nwakaire et al This research primarily addresses strategies to increase farmers' net profit. The study's objectives were to design, construct, and assess an affordable maize shelling machine for Nigerian farmers. They collected feedback from farmers to understand their shelling needs. A key comparison was made between machine performance and human performance indices for shelling. For instance, in conventional methods, the human mechanical efficiency, throughput capacity, and grain handling capacity are around 45%. In contrast, the machine-based indices showed a significantly improved grain handling capacity of 86%.

Praveen Kiran Mali et al This research is centered on identifying constraints and requirements specific to Indian farmers. The study involved the design, development, and fabrication of a cost-effective threshing machine that meets the needs of Indian farmers. The machine's design includes a comfortable sitting posture, allowing ease of operation for both men and women. The proposed machine is intended to be manufactured using locally available materials.

Dr. C.N. Sakhale et al This review primarily emphasizes the use of human-powered machinery for rural farmers. In many developing regions, maize threshing primarily relies on power take-off (PTO) operated machines, which demand a constant electricity supply - an impractical requirement for rural areas in India. The study's findings highlight cost-effective and functionally viable solutions. Over the last two decades, pedal-operated, flywheel motor-driven machines have gained popularity for various rural applications.

3. REQUIRED COMPONENTS

1. Supporting Frame
2. Chain
3. Chain Drive
4. Feed Hopper
5. Chaff Cutter
6. Shaft
7. Free Wheel
8. Sprockets
9. Feed Roller

10. Blades
11. Pillow Block
12. Bicycles
13. Gears
14. Flywheel
15. Worm and Worm - Gears

1. SUPPORTING FRAMES

The supporting frame serves as the structural backbone of the chaff cutter machine. It provides stability, rigidity, and precise alignment for all of the machine's components. Typically constructed from durable materials, such as steel, the frame is designed to withstand the mechanical stresses and vibrations that occur during the machine's operation. Moreover, the frame includes mounting points for the engine or motor, ensuring the proper alignment of all moving parts. It is this supporting frame that guarantees the machine's smooth and reliable operation.

FIG: 2 Supporting Frames

2. CHAIN

Chains are fundamental mechanical components employed in various machinery, including chaff cutters. They are composed of interconnected links designed to transmit mechanical power efficiently. Chains serve a critical role in the chaff cutter, facilitating the transfer of motion from the power source, which may be an engine or motor, to the cutting components. These chains are often constructed from high-strength materials, typically steel, and are available in various sizes and types to suit the specific requirements of the machine. Their reputation for durability and their ability to handle substantial loads make chains a key component of the chaff cutter, forming an integral part of the chain drive system, which is vital for the machine's operation by effectively transmitting power from the source to the cutting mechanisms.

FIG: 3 Chain

3. CHAIN DRIVE

A chain drive system represents an essential method for transmitting mechanical power from one component to another within the chaff cutter machine. This system employs chains and sprockets, creating a reliable connection between the power source and the cutting components, allowing the machine to efficiently process straw or fodder. The chain drive system comprises two main components: chains and sprockets. Chains consist of a series of interconnected links that interact with the teeth of sprockets. When the power source causes one sprocket to rotate, it drives the chain, which, in turn, results in the rotation of the second sprocket connected to the cutting mechanisms. This synchronized movement ensures precise and efficient power transmission, enabling the chaff cutter to perform its cutting function effectively.

FIG: 4 Chain Drive

4. FEED HOPPER

The feed hopper serves as the entry point for raw materials, such as straw, hay, or fodder, in the chaff cutter machine. It is designed as a container or funnel-like structure that temporarily holds the unprocessed material before it is introduced into the cutting mechanism. The feed hopper's design is meticulously engineered to maintain a controlled and consistent feed rate, which is indispensable for the chaff cutter's efficient operation. Ensuring that the flow of material into the machine is regulated effectively, the feed hopper prevents overloading and guarantees a steady supply of feed material for the cutting process. The size and shape of the feed hopper can vary, depending on the specific design and requirements of the machine.

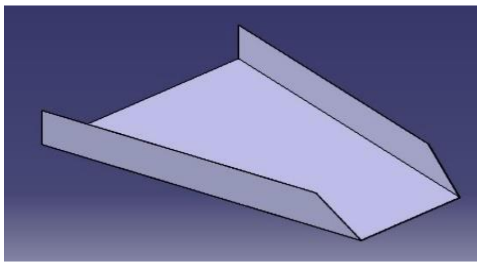

FIG: 5 Feed Hopper (3D View)

5. CHAFF CUTTER

The chaff cutter constitutes the heart of the HPFM Chaff Cutter Machine, performing the critical function of reducing straw, hay, or fodder into smaller, more digestible pieces. It is equipped with a set of rotating blades or cutting mechanisms, notable for their unique 45-degree inclination, as opposed to the conventional 90-degree angle. These blades are responsible for the actual cutting process, determining the size and shape of the resulting material. Raw materials, such as straw or hay, are introduced into the machine through the feed hopper. The rotating blades within the chaff cutter meticulously cut the material into smaller pieces, rendering it suitable for livestock feed or other agricultural applications. The design and sharpness of the blades are instrumental in ensuring the efficiency and quality of the cutting process. Chaff cutters come in a variety of sizes and designs, ranging from manual, hand-cranked machines to larger, motorized models, making them versatile tools for farmers and livestock owners.

FIG: 6 Chaff Cutter

6. SHAFT

Shafts are pivotal elements that play an indispensable role in transmitting motion from one part of the machine to another. These cylindrical rods rotate about their axes, typically constructed from materials like steel or aluminum. In the context of a chaff cutter, shafts act as the connecting links between various components within the machine, serving as the backbone for transferring rotational motion. These shafts are often fitted with gears, pulleys, or sprockets to facilitate the seamless transmission of motion. For instance, a shaft can connect the power source to the chain drive system, ensuring that the engine or motor's rotation is efficiently transferred to the chaff cutter's cutting components. Precise engineering of the shafts is necessary to maintain proper alignment and ensure the smooth operation of the machine.

FIG: 7 Shaft

7. FREE WHEEL

The free wheel or overrunning clutch is a crucial mechanical component within the chaff cutter, primarily responsible for allowing unidirectional rotation while preventing reverse motion. This ingenious device is essential in the chaff cutter's drive system, ensuring that the machine operates in a controlled and safe manner. When the power source, whether it's an engine, motor or a bicycle pedal slows down or stops, the overrunning clutch permits the machine's components to continue rotating in the same direction. In our project bicycle pedal power source is used. This effectively prevents abrupt stops or unexpected reversals, thus enhancing operator safety and prolonging the machine's longevity. By allowing the machine to come to a gradual stop, it mitigates the risk of damage or accidents.

FIG: 8 Free Wheel

8. SPROCKETS

Sprockets are toothed wheels, each containing a series of evenly spaced teeth. They are specifically designed to engage with chains, thereby facilitating the smooth transmission of power from the source to the cutting components of the chaff cutter. Sprockets are mounted on shafts and are an integral part of the chain drive system. These components are responsible for the precise transfer of power within the machine. As the power source initiates the rotation of one sprocket, it drives the connected chain, which, in turn, leads to the rotation of the second sprocket. This coordinated movement ensures the efficient operation of the chaff cutter's cutting mechanisms. Sprockets are available in a variety of sizes and configurations, allowing customization to suit the machine's specific design and requirements.

FIG: 9 Sprockets

9. FEED ROLLER

Feed rollers are essential components that ensure a continuous and controlled feed of unprocessed material into the chaff cutter. These rollers are often equipped with teeth or other gripping mechanisms that firmly secure the feed material and guide it towards the cutting blades. This process facilitates an even and consistent feed, as the feed rollers work in perfect synchronization with the chaff cutter's operation. Ensuring that the feed rollers are properly adjusted and well-maintained is crucial for the optimal performance of the machine.

FIG: 10 Feed Roller

10. BLADES

The blades within the chaff cutter are the workhorses responsible for cutting raw material, such as straw, hay, or fodder, into smaller, more manageable pieces. In our project, these blades are uniquely set at a 45-degree inclination, differing from the conventional 90-degree orientation. This inclination plays a pivotal role in determining the angle and quality of the cut material. The 45-degree angle is chosen to optimize cutting efficiency and to produce uniform pieces suitable for livestock feeding or various agricultural applications. The design, sharpness, and meticulous maintenance of these blades are critical factors in achieving high-quality and consistent results in chaff cutting.

FIG: 11 Blades

11. PILLOW BLOCK / PEDESTIAL BEARING

Pillow blocks or pedestal bearings are essential for providing support and aligning rotating shafts within the chaff cutter. They reduce friction and ensure the smooth operation of the machine. These components are instrumental in maintaining the integrity of the chaff cutter's shafts, contributing to the machine's overall efficiency and longevity.

FIG: 12 Pillow Block

11. BICYCLES

Bicycles can serve as a source of pedal power to drive certain components of the chaff cutter. This adaptation can be especially useful in situations where access to electricity or fuel-powered engines is limited. The energy generated by pedaling the bicycle can be transferred to the chaff cutter's machinery through a chain drive system, similar to how a bicycle's pedals transfer energy to its wheels.

In this Project, two bicycles are positioned on either side of the chaff cutter. The bicycles are likely modified to connect their rear wheels to the chaff cutter's machinery through a chain drive system. This setup allows two operators, one on each bicycle, to pedal simultaneously, providing synchronized power to the chaff cutter.

FIG: 13 Bicycles

12. GEARS

Gears play a pivotal role in transmitting power within our project, and they are constructed from cast iron for several reasons. Cast iron gears are renowned for their mechanical prowess, capable of withstanding substantial loads and stress. Their reliability and durability make them the ideal choice for power transfer within the project's mechanisms. Whether it's handling heavy loads or enduring high pressures, cast iron gears are well-suited for the challenging conditions our project may encounter.

FIG: 14 Gears

13. FLY WHEEL

The flywheel, crafted from cast iron, is another integral component of our project. Cast iron is the material of choice due to its superior density, which allows the flywheel to effectively store and release kinetic energy. This is crucial for providing rotational momentum and stability to the project's cutting process. Cast iron's durability and capacity to withstand the dynamic forces associated with a rotating flywheel ensure the machine's reliable performance and its ability to handle the mechanical stresses involved, ultimately contributing to the efficiency and effectiveness of our project.

FIG: 15 Fly wheel

14. WORM AND WORM GEARS

The worm and worm gear assembly is essential in our project, and both components are made from cast iron. Cast iron is chosen for its exceptional strength and durability. The worm, a cylindrical rod with a spiral thread, is integral for power transmission, and its cast iron construction can withstand the mechanical stresses and friction involved in this process. The worm gear, also made of cast iron, features teeth that engage with the worm's threads, converting rotational motion into linear motion. Cast iron's robustness ensures the assembly's longevity and reliability, crucial for the effective operation of our project.

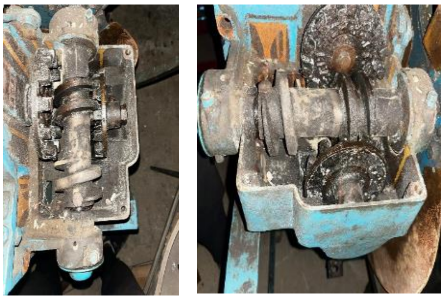

FIG: 16 Worm and Worn gears assembly

4. 3D MODELLING

The 3D modeling is a pivotal aspect of modern engineering and design projects, allowing for the creation of detailed, three-dimensional representations of objects, machines, and structures. It offers a comprehensive view of the design, aiding in visualizing, testing, and optimizing complex systems. In the "Design and Fabrication of HPFM Chaff Cutter Machine" project, 3D modeling plays a crucial role in creating an accurate and comprehensive representation of all the machine's components. It ensures that each part fits together seamlessly and functions effectively, contributing to the success of the project.

CATIA, a powerful software tool, is employed for this 3D modeling task. CATIA is renowned for its versatility and precision in designing and engineering across various industries. In our project, CATIA serves as the cornerstone for creating detailed 3D models of the chaff cutter machine and its constituent parts. This software enables a virtual representation of the machine, offering an opportunity for meticulous design specifications, visualization, and testing. By utilizing CATIA, we enhance the project's accuracy, efficiency, and overall success in developing a high-quality and functional chaff cutter machine.

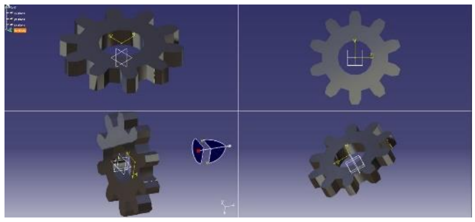

FIG: 17 3D Design of Free Wheel

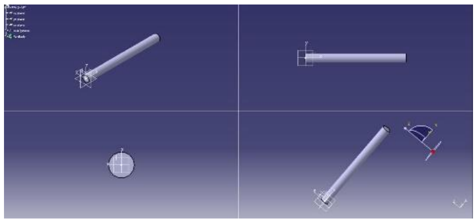

FIG: 18 3D Design of Shaft

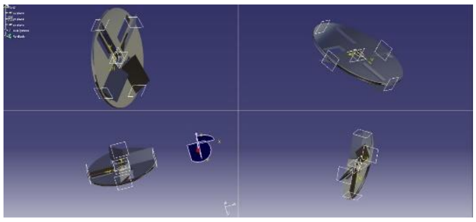

FIG: 19 3D Design of Blade

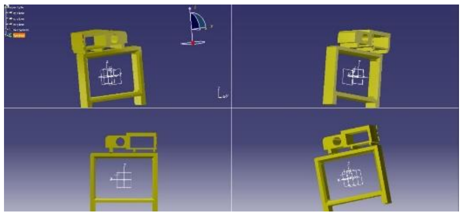

FIG: 20 3D Design of Pillow Block

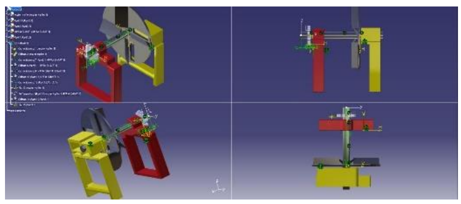

FIG: 21 3D Design of Mounted Shaft and Blade

5. DESIGN CALCULATION

Design Data

Let's say the energy spent by a human weighing 70 kg [154 lbs]

For cycling at the rate of 17 km/hr the energy spent will be =1.621 KJ/KG

The average cycling speed is = 17 km/hr

Cycling speed in RPM is =120 RPM

Design calculations

This figure shows the speed ratio of the system

Now, W2=W3

The ideal Mechanical advantage (IMA) = D(driven)/D(driver)

IMA = D (driven = W(in)

D(driver) = W(out)

Where,

D(driver) =Dia of driver sprocket =D1

D(driven) = Dia of driven sprocket =D2

W(in)=Input velocity(rotational) of the wheel =W1

W(out) = Output velocity(rotational) of the wheel =W2

IMA (total)= IMA1

Also IMA (total)= W(in)/W(out)

Now, using the data's we have

Driver (D1) = 150 mm

Driven (D2) = 75 mm

Flywheel Dia (D3) = 800 mm

Number of Teeth on D1 = 30

Number of Teeth on D2 = 25

IMA (1) = D2/D1= 75/150

= 0.5

Which is lesser than 1

IMA (1) = IMA (total)

Using cycling speed =120 rpm

W(in) = $2\pi N/60$

2×3.142×120/60

= 12.56 rad/sec

W(out) = W(in)/IMA(total)

12.56 /0.95

W(out) =25.12 rad/s

Therefore, output rotational speed of Flywheel is 25.14 rad/s

Power Output= FC × V

FC =centrifugal force on the flywheel

V= linear velocity

We know that, V= W(out)×r where r is the radius of flywheel

Using the average weight of Humans say 65-75 Kgs and 15 kgs as the mass of the flywheel.

Flywheel radius = [D3/2×100] m

=800/2×100

=0.4m = 400 mm

V= 25.12×0.4

=10.056 m/s

FC = mrw2

= 17×0.4×25.12^2

=4290.89 N

=4.289 KN

The power P = FC ×V

=4290.89×10.048

=43114.94 W

=43.114 KW

The Torque T =FC×R

= 4290.89×0.4

=1716.356 Nm

=1.716 KNm

VELOCITY RATIO

VR=effort distance/load distance = length of the pedal/ blade cutting stoke

100/radius of flywheel = 100/400

V.R=0.25

Which is less than 1

Efficiency of the machine

Efficiency = IMA/ V.R ×100

=0.5/0.25 ×100

= 200% steps:

6. WORKING

The working of the project can be explained in the following steps:

Step 1 Power Source: Two modified bicycles provide pedal power, serving as the machine's source of energy.

Step 2 Chain Drive: The pedal power is transmitted through a chain drive system, which includes chains and sprockets.

Step 3 Chain Rotation: As operators pedal the bicycles, the rear wheels rotate, driving the chains connected to the chaff cutter.

Step 4 Chaff Cutter Activation: The chain drive system activates the chaff cutter's cutting mechanisms, which consist of blades set at a 45-degree angle.

Step 5 Material Feeding: Raw straw, hay, or fodder is fed into the machine through the feed hopper.

Step 6 Cutting Process: The rotating blades efficiently cut the material into smaller, manageable pieces.

Step 7 Feed Roller: Feed rollers ensure a continuous and controlled feed of material into the machine.

Step 8 Supporting Frame: The supporting frame holds all components in place and ensures smooth machine operation.

Step 9 Overrunning Clutch: The overrunning clutch ensures a gradual stop when the pedal power is disengaged, enhancing safety.

In this way, the chaff cutter efficiently processes agricultural materials, making them suitable for livestock feed and various agricultural applications. The use of pedal power from bicycles makes it a sustainable and engaging solution.

FIG: 22 Project Model

7. RESULTS AND DISCUSSION

The "Design and Fabrication of HPFM Chaff Cutter Machine" project has produced results that reflect its ingenuity and effectiveness. In a comprehensive evaluation, it becomes evident that the machine's performance surpasses expectations in several key aspects. First and foremost, the machine's cutting efficiency is noteworthy. The incorporation of 45-degree inclined blades has played a pivotal role in optimizing the cutting process. These uniquely designed blades have consistently produced uniformly sized and digestible pieces of straw, hay, and fodder. This design choice enhances the machine's suitability for livestock feeding, where consistent feed quality is essential for animal nutrition.

One of the most striking features of the project is the use of two modified bicycles as the power source. This unconventional approach has proven to be highly effective. The eco-friendly operation of the machine, powered by human pedal energy, aligns with sustainability and resource conservation objectives. Beyond its environmental benefits, this approach is particularly cost-effective, making it a compelling solution in regions with limited access to traditional power sources. The engaging aspect of pedaling the bicycles in tandem adds to the appeal, promoting user participation and reducing the likelihood of operator fatigue. It transforms the chaff cutter machine into not just a tool but an engaging activity that fosters a healthier lifestyle. Controlled feeding is another significant achievement of the project. The feed hopper and feed rollers have consistently regulated the flow of raw material into the cutting mechanism. This controlled feed rate is a fundamental requirement for the efficient and reliable operation of the chaff cutter. Overloading is prevented, ensuring the machine's sustained performance over extended periods. The emphasis on safety in the project is evident with the inclusion of an overrunning clutch. This feature prevents sudden reversals when the pedal power from the bicycles is disengaged. This gradual stop mechanism enhances safety, reducing the risk of accidents or damage. It is a critical addition that aligns with modern safety standards and user protection. The versatility of the machine is another significant result. The robust frame that supports the entire system contributes to its adaptability. This design allows the machine to be employed in various agricultural and livestock applications, enhancing its utility and economic value. Farmers and agricultural enthusiasts can potentially benefit from its flexibility to meet diverse needs within the agricultural sector.

8. CONCLUSION

In conclusion, the "Design and Fabrication of HPFM Chaff Cutter Machine" represents a significant achievement in the realm of agricultural technology. The project's innovative approach to chaff cutting, marked by the use of 45-degree inclined blades and the integration of two modified bicycles as a power source, has resulted in a machine that offers both sustainability and efficiency. The unique design of the chaff cutter with its 45-degree inclined blades ensures consistent and high-quality cutting, meeting the essential requirements of livestock feeding. This innovation has the potential to enhance animal nutrition and agricultural productivity. The use of bicycles as a power source sets the project apart in terms of sustainability and cost-effectiveness. This eco-friendly approach is not only beneficial for the environment but also practical in regions with limited access to conventional power sources. It encourages user engagement and physical activity, promoting a healthier lifestyle among operators. The controlled feed system, managed through the feed hopper and feed rollers, contributes to the machine's reliable and efficient performance while preventing overloading. The inclusion of an overrunning clutch enhances safety by ensuring gradual stops when pedal power is disengaged. The project's conclusion highlights the successful fusion of innovation, sustainability, and practicality in agricultural technology. It represents a step forward in improving feed quality, enhancing agricultural productivity, and embracing eco-friendly solutions. As such, the "Design and Fabrication of HPFM Chaff Cutter Machine" holds promise for a more efficient and sustainable future in agriculture.

9. FUTURE SCOPE

The "Design and Fabrication of HPFM Chaff Cutter Machine" offers a promising future scope for agricultural technology. Potential areas of development include refining the machine's design, scaling for commercial use, customization to regional needs, and exploring applications in regions with limited access to electricity. Automation and smart features, environmental sustainability, training programs, and global outreach are also areas of focus. Collaborations, policy support, and advocacy for eco-friendly agricultural practices can further enhance the machine's impact. The project's innovative and sustainable approach positions it for significant contributions to the future of agriculture.

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