The Crop Harvester Machine for Jowar and Bajra

Mukund Nalawade[1] , Vivek Sanap[2] ,Vrushabh Warke[3] ,Anushka Turak[4] , Varad Vanage[5] , Shreyas Dalvi [6]

[1,2,3,4,5,6] *Vishwakarma Institute of technology,Pune , India .*

[1]mukund.nalawade@vit.edu, [2]vivek.sanap20@vit.edu , [3]vrushabh.warke20@vit.edu, [4]anushka.turak21@vit.edu , [5]varadvanage20@vit.edu , [6]shreyas.dalvi20@vit.edu ,

Abstract:

In this review paper, we delve into the intricacies of sorghum harvesting in India, tracing the historical development of harvesting technology and examining the production dynamics of sorghum and related crops like bajra. We explore traditional and modern methods of cutting sorghum, assess the impact of mechanized harvesting on farmer livelihoods and agricultural practices, and evaluate the advantages and disadvantages of sorghum harvesting machines. Through a nuanced understanding of the challenges and opportunities in sorghum cultivation, we aim to inform future advancements and innovations in agricultural technology, promoting sustainable and inclusive agricultural practices that benefit farmers, communities, and ecosystems alike.

Keywords: *Agriculture , Crop Harvester , Slider crank mechanism ,3D modelling* **.**

1 INTRODUCTION

Sorghum, a resilient and versatile cereal crop, holds a prominent position in India's agricultural landscape, serving as a vital source of food, fodder, and income for millions of farmers across the country. In India, sorghum occupies a significant portion of agricultural land, with farmers cultivating the crop in diverse agro-climatic regions ranging from arid and semi-arid zones to regions with abundant rainfall. India ranks fifth in total sorghum production, with 4.23 million tonnes grown in an area of 3.90 million hectares in 2021-22. In the kharif season of 2022-23, sorghum production was estimated at 1.69 million tonnes (1st advance estimates) in an area of 2.94 million hectares.

Historically, sorghum cultivation in India has been intertwined with traditional farming practices, where manual harvesting methods, such as hand-cutting, prevailed. However, the reliance on manual labor for sorghum harvesting posed numerous challenges, ranging from labor shortages to inefficient harvesting practices, inhibiting the realization of the crop's full potential.In response to these challenges, the introduction of mechanized harvesting machines heralded a new era in sorghum cultivation, offering farmers an alternative to labor-intensive manual methods. The transition from manual to mechanized harvesting represented a significant paradigm shift, driven by technological advancements and the pressing need for more efficient and sustainable agricultural practices.

Several types of sorghum harvesting machines are used in India, each with its own set of features, advantages, and limitations. One common type is the reel harvester, which utilizes a rotating reel with blades or fingers to cut the sorghum stalks. Another type is the header harvester, which attaches to a combine harvester and uses a cutting header to cut and gather the sorghum stalks for further processing. Additionally, some farmers employ stripper harvesters, which strip the grain from the stalks using rotating rollers or brushes, particularly in regions where sorghum is grown for forage rather than grain production. The adoption of sorghum harvesting machines has revolutionized the way sorghum crops are harvested in India, enabling farmers to optimize their harvesting operations, improve overall productivity, and reduce labor costs. However, the widespread adoption of mechanized harvesting machines also presents certain challenges, including the initial investment costs, maintenance requirements, and the need for specialized skills and training.

2 LITERATURE REVIEW

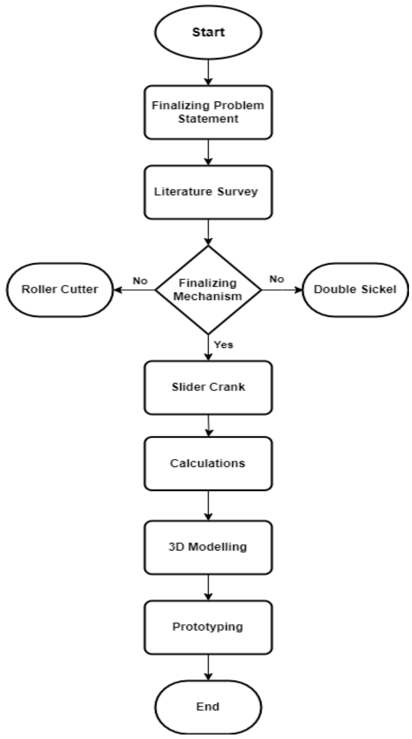
In this paper titled “Review of Agricultural Crop Harvesting Mechanisms. “This comprehensive review paper provides a detailed analysis of various harvesting mechanisms employed in agriculture, ranging from traditional sickle bars to modern reel and rotary mechanisms. It meticulously examines the advantages and limitations of each mechanism in terms of crop compatibility, operational efficiency, and maintenance requirements. The paper serves as a foundational resource for understanding the landscape of crop harvesting technologies, guiding researchers and practitioners in selecting the most suitable mechanisms for specific agricultural contexts.[1] In this paper "Design and Development of Sickle-Bar Mower for Small Scale Agricultural Applications. “This pioneering study presents the meticulous design and development process of a sickle-bar mower tailored for small-scale agricultural operations. From conceptualization to field testing, the paper delves into the intricate design considerations, material selection rationale, and rigorous performance evaluations conducted to ensure the mower's effectiveness in real-world settings. The insights gleaned from this study contribute to the advancement of harvesting equipment design, particularly for small-scale farming communities.[2] In this research work "Emerging Trends in Post-Harvest Processing Technologies for Crop Residue Utilization."Post-harvest processing technologies play a crucial role in maximizing resource utilization and minimizing waste in agricultural production systems. This paper examines emerging trends in post-harvest processing technologies aimed at utilizing crop residues efficiently. From biomass conversion and bioenergy production to value-added product development and circular economy approaches, the study explores innovative techniques for valorizing crop residues and reducing environmental impact. By highlighting technological advancements, economic opportunities, and policy implications, the paper provides insights into fostering sustainable post-harvest processing practices that contribute to the resilience and sustainability of agricultural systems.[15] In this research paper "Application of Machine Learning Techniques in Crop Yield Prediction." This paper explores the application of machine learning techniques in predicting crop yields. By analyzing historical data on weather patterns, soil conditions, and crop performance, machine learning models can provide valuable insights into future yields.

The study examines different algorithms, data sources, and challenges associated with crop yield prediction, offering recommendations for improving accuracy and reliability.[16] In this paper "Role of IoT in Smart Agriculture: A Review."Internet of Things (IoT) technology is revolutionizing agriculture by enabling real-time monitoring and control of farming operations. This review paper discusses the role of IoT in smart agriculture, focusing on its applications in crop harvesting. From sensor-based crop monitoring to automated harvesting systems, IoT offers numerous opportunities to enhance efficiency and productivity in crop harvesting while reducing resource inputs.[17]

In this research paper "Advancements in Crop Harvesting Equipment for Smallholder Farmers."Smallholder farmers face unique challenges in crop harvesting due to limited resources and landholdings. This paper examines recent advancements in crop harvesting equipment tailored for smallholder farmers. From low-cost hand tools to small-scale mechanized harvesters, the study explores innovative solutions aimed at improving productivity and livelihoods in smallholder agriculture.[18] in this paper "Impact of Harvesting Techniques on Post-Harvest Losses: A Case Study." Post-harvest losses remain a significant challenge in agricultural supply chains, with harvesting techniques playing a crucial role. This paper investigates the impact of harvesting techniques on post-harvest losses, using a case study approach. By analyzing factors such as timing, method, and handling practices, the study identifies opportunities to reduce losses and improve food security.[19] In this research paper "Mechanization of Vegetable Harvesting: Challenges and Opportunities."Vegetable harvesting presents unique challenges due to the diversity of crops and their delicate nature. This paper discusses the challenges and opportunities in the mechanization of vegetable harvesting. From specialized harvesting equipment to robotic systems, the study explores innovative solutions aimed at increasing efficiency and reducing labor dependency in vegetable production systems.[20]In this research paper "Role of Drones in Precision Harvesting: A Review."Drones, or unmanned aerial vehicles (UAVs), offer promising applications in precision agriculture, including crop harvesting. This review paper examines the role of drones in precision harvesting, focusing on their capabilities in crop monitoring, yield estimation, and autonomous harvesting. By synthesizing current research and technological developments, the study highlights the potential of drones to revolutionize harvesting practices.[21]"Innovations in Fruit Harvesting Technologies: A Comprehensive Review."Fruit harvesting requires specialized techniques and equipment to ensure quality and minimize damage. This comprehensive review explores innovations in fruit harvesting technologies, ranging from robotic arms to vacuum-assisted harvesters. The study assesses the effectiveness, cost-effectiveness, and scalability of different technologies, providing insights into their adoption and implementation in fruit production systems. "Integration of GIS and Remote Sensing in Crop Harvesting Management.[22]"Geographic Information Systems (GIS) and remote sensing technologies offer valuable tools for crop harvesting management. This paper examines the integration of GIS and remote sensing in crop harvesting, focusing on applications such as field mapping, yield monitoring, and harvest planning. By leveraging spatial data and imagery, farmers can optimize harvesting operations and make informed decisions to maximize yields and profitability. [23]"Impact of Harvesting Practices on Soil Health: A Review."Harvesting practices can have significant implications for soil health, including compaction, erosion, and nutrient depletion.

This review paper evaluates the impact of harvesting practices on soil health, drawing on empirical studies and field observations. By analyzing factors such as equipment design, timing, and field conditions, the study identifies strategies to minimize soil disturbance and preserve soil fertility during harvesting operations[24]."Social and Economic Impacts of Mechanized Harvesting: A Case Study."The adoption of mechanized harvesting can have profound social and economic impacts on farming communities. This case study examines the social and economic implications of mechanized harvesting in a specific agricultural context. By assessing factors such as labor displacement, income distribution, and technology adoption, the study provides insights into the opportunities and challenges associated with mechanization in agriculture.

3 METHODOLOGY



The project commenced with the identification and finalization of the problem statement, specifically focusing on the development of a crop cutting machine tailored for harvesting Jowar and Bajri. Initially, a comprehensive review of existing literature, including various research papers, patents, and surveys conducted among farmers, was undertaken to understand the current technologies and challenges in the field. This review provided insights into the requirements and limitations of current crop cutting mechanisms.Subsequently, the focus shifted to the conceptualization and evaluation of potential mechanisms for the crop cutting machine. Three mechanisms were considered: the roller cutter, the slider crank, and the double sickle mechanism. After a detailed analysis of each mechanism’s complexity, efficiency, and cost, the slider crank mechanism emerged as the most straightforward and cost-effective solution. This mechanism was selected for further development due to its simplicity and feasibility in reducing manufacturing costs.

Following the selection of the slider crank mechanism, stress and force calculations were performed to ensure the mechanical viability and durability of the design. These calculations were crucial in determining the appropriate materials and dimensions for the components to withstand operational loads.

For the detailed design phase, 3D modeling of the crop cutting machine was carried out using Fusion 360. This software facilitated the visualization and refinement of the mechanism, ensuring all parts fit and functioned correctly within the assembly. To validate the design under operational conditions, static analysis was conducted using Soliworks. This analysis helped identify potential points of failure and allowed for optimization of the design to enhance reliability and performancThrough this systematic approach, the project progressed from problem identification to the development and validation of a practical and cost-effective crop cutting machine for Jowar and Bajri harvesting and prototyping is developed . You can see all the workflow in above chart.

4 CALCULATION

1. Mass of reciprocating part = 0.03818 kg
2. Mass of Connecting rod part = 0.01196 kg
3. Stroke Length = 50 mm r_2= 25 mm
4. Length of connecting rod between centers = 100 mm
5. Radius of gyration of Connecting rod about an axis through C_G = 28.8683 mm
6. Distance of C_G from both centers = 50 mm
7. Motor Speed = 350 rpm (acw)

To find inertia torque on crank when crank has turned 60° from inner dead centre,

$$\theta_2 = 60^\circ \quad N_2 = 350\, rpm \quad r_2 = 25\, mm$$

$$\omega_2 = \frac{2\pi N_2}{60} = \frac{2\pi \times 350}{60} = 36.6519\, rad/s$$

$$v_2 = r_2 \times \omega_2 = 25 \times 36.6519 = 916.2978\ mm\frac{rad}{s}$$

$$v_2 = 91.62978\ {rad}/{s}$$

Let scale for velocity diagram be 15 cm = 1 cm

Table to make Velocity Diagram

LinkName	Vector	Magnitude	Direction	Additional Information
AB	V_{ab}	91.62978	Clockwise	Perpendicular to AB Link
BD	V_{bd}	Unknown	Unknown	Perpendicular to BD Link
AD	V_{ad}	Unknown	Unknown	Parallel to AD Link

Now By using Velocity Diagram V_{bd} = 3.2 cm x 15 = 48 cm/s

$W_{bd} = V_{bd} / |BD|$ = 4.8 rad/sec

Table to Draw Acceleration Diagram

Link Name	Centripetal Acceleration	Tangential Acceleration	Sliding Acceleration	Additional Information
AB	3358.4	0	NA	--
BD	Known	Unknown	NA	Oscillation
AD	NA	NA	Known	Sliding

The Centripetal Acceleration of Connecting Rod is 25 x 36.6519 x 36.6519 = 3358.4 cm/s^2
The Centripetal Acceleration of the Piston is the magnitude of BD x Square of its Angular velocity = 10 x (4.8)^2 = 230.4 cm/s^2

Let scale to acceleration diagram be 500 cm = 1cm

Now by using acceleration diagram

a_p= 266 x 500 = 1330 cm/s^2

a_{cr}= 418x500 = 2090 cm/s^2

f_{bd} = 5.82 x 500 = 2910 cm/s^2

Let E, be inertia force of piston
F_1 = mass of piston x a_p
F_1 = 0.03818 x 1330 kg Cm/s^2
F_1 = 50.7794 kg cm/s^2
F_1= 0.5077 N
Let E_2 be inertial force of piston r
F_2=mass of connecting rod x a_{cr}
= 0.01196x 2090 Cm/s^2 kg
= 24.9964 kg cm/s^2
F_2 = 0.2499 N

let F_3be wight of piston
F_3=0.03818×98=037.41 N

Let F_4 be weight of connecting rod
F_4=0.01196x180
F_4=0.1172N

Now Ff be friction force between piston and cylinder
Ff = $\mu M_P = 0.5 \times 0.03818 = 1.909 \times 10^{-3}$N = 0.001909 N
Fp net force reuire to cut crop is 50N

$$F_t = F_p - F_1 - F_f = 50 - 0.5077 - 0.001909$$

$$F_t = 49.490391$$

Let T2 be inertia torque of connecting rod = I∝
T2 = I∝ = $M_2 k^2 \propto$

$$\propto = \frac{f^1{}_{b^1 d^1}}{BD} = \frac{5.8 \times 500}{10} = 290\ rad/s^2$$

T2= $0.01196 \times\ 0.028868^2\ \times 290 = 2.8904 \times 10^{-3} Nm\ (Anticlockwise\ Direction)$

$$\gamma = \frac{T_2}{F_2} = \frac{2.8904 \times 10^{-3}}{0.2499} = 0.01156m = 1.156cm$$
$$\gamma = 1.156cm$$

Let x,y,z,w be the perpendicular distance between I_{13} & F_{2} $_{,}F_{t}, F_{4}$ $force\ respectively$

x= 15.9 cm
F_2 = 0.2499 N
y= 19.5cm
F_{t}=49.490391 N
z=6.2cm
F_{4}=0.1172 N
W= 20 m

F_{5}={F_{t}*y-(F_{z} * x)-(F_{4}*z)}/{w}
F_ {5}={49.490391*19.5-(0.249*15.9).-(0.1172*6.2)}/{20}
F_ {5}={965.0626-(3.97341)-.(0.72664)}/{20}

Fs=48.01812 N

let T be the inertial. torque on crank Shaft .
T= Fsx length of crank arm
T= 48.01812 × 0.025
T=1.2004 Nm

Power = Torque x angular velocity
Power= 1.2004 X 36.6519 watt
Power= 43.9988 watt

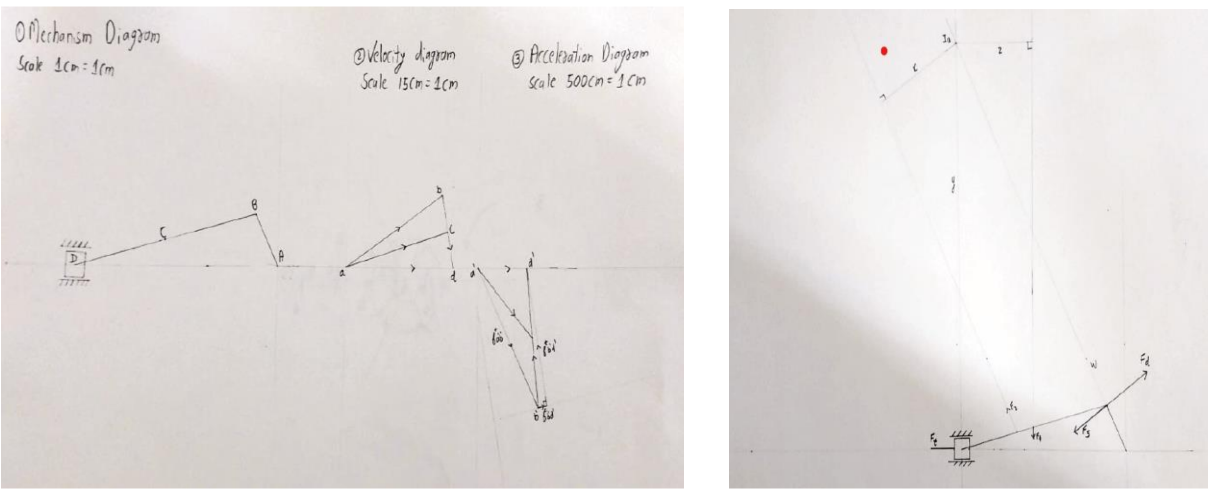


Figure 1 Velocity and acceleration diagram

5 RESULTS AND DISCUSSION

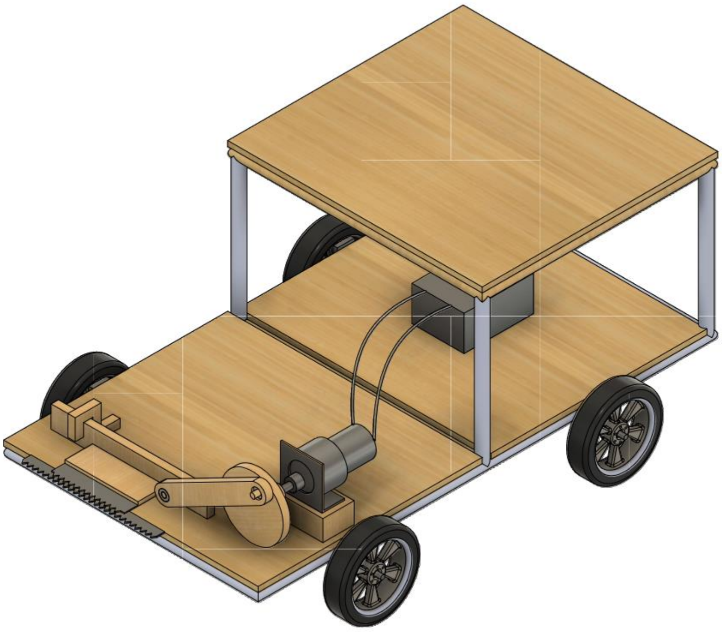


Figure 2 3d Model

The structural framework of the design utilizes a PVC pipe with a diameter of 13 mm. This material was specifically chosen due to its standard size, which ensures easy procurement and compatibility with other components. The use of PVC offers several advantages that make it ideal for this application. Its lightweight nature makes the framework easy to handle and maneuver, reducing the overall weight of the structure without compromising strength. Furthermore, PVC is corrosion-resistant, ensuring long-term durability and reliability even in potentially harsh environments. Additionally, PVC is easy to cut and join, which simplifies the construction process and allows for precise assembly of the framework.

For the mounting of the battery and the entire mechanism, a piece of plywood measuring 280 mm by 258 mm was used. Plywood was selected because it offers an excellent strength-to-weight ratio, providing substantial strength while remaining relatively lightweight. This characteristic is crucial for maintaining the structural integrity of the mounted components without adding unnecessary bulk. Plywood is also known for its durability, which ensures that it can withstand the operational stresses and maintain stability over time. Its cost-effectiveness makes it a practical choice, particularly for projects with budget constraints. Moreover, plywood is readily available and easy to work with, allowing for straightforward cutting, drilling, and shaping to fit the specific requirements of the design.

The slider-crank mechanism, a central component of the design, was crafted from Medium Density Fibreboard (MDF). MDF was chosen for this purpose because of its uniform density and smooth surface, which are essential for achieving precise machining and a high-quality finish. Each part of the slider-crank mechanism, including the crank, connecting rod, and slider, was meticulously laser cut from MDF.

This method ensures exceptional accuracy and consistency in the dimensions of each component, which is vital for the smooth and efficient operation of the mechanism. The joints within the mechanism were made from plain carbon steel, selected for its outstanding strength and durability. Carbon steel's wear resistance is particularly important for the moving parts, ensuring long-lasting performance and minimal maintenance.

The wheels used in the prototype are standard wheels made of plastic and rubber. These materials were specifically chosen for their lightweight properties, which help to minimize the overall load on the mechanism, thereby enhancing its efficiency. Plastic provides a rigid and durable structure for the wheels, while rubber offers the necessary flexibility and grip. This combination ensures that the wheels can provide sufficient traction for smooth and reliable movement of the prototype across various surfaces. The lightweight nature of these materials also contributes to the overall ease of handling and maneuverability of the prototype, making it well-suited for its intended application.

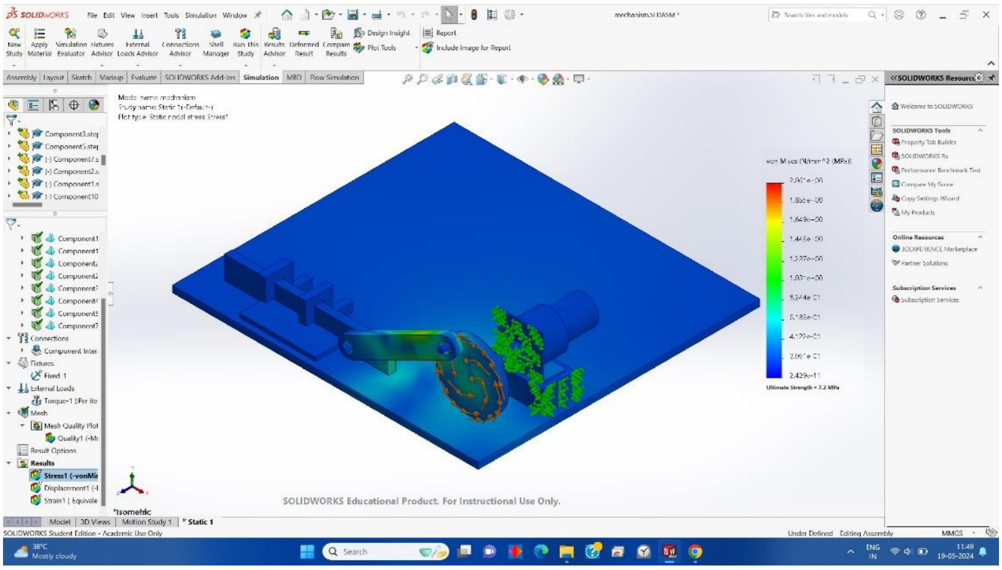


Figure 3 Static Analysis of model

The tensile strength of Medium Density Fibreboard (MDF) is specified at 18 MPa, while its compressive strength is 10 MPa. Given that MDF components are often bonded with adhesive, a safety factor of 2.5 is employed to ensure robustness. By dividing the tensile strength by this safety factor, the permissible stress value is determined to be 7.2 MPa. This precautionary measure aims to guarantee the structural integrity and dependability of the MDF parts when subjected to stress. When considering the force necessary for cutting crops, the maximum required force is 50 N, and the minimum is 30 N. For design considerations, the higher force of 50 N is used to ensure that the mechanism can endure the most demanding load scenario. This approach ensures the mechanism's capability to handle the maximum expected force without the risk of failure.

The design process involved defining boundary conditions such as securing the motor and applying a 50 N force on the piston, along with detailing all relevant joints in the slider-crank mechanism. A comprehensive stress analysis was then performed, taking into account all the forces and constraints to accurately represent operational conditions.

The analysis revealed a maximum stress of 2.061 MPa.Given that this observed maximum stress of 2.061 MPa is well below the permissible stress value of 7.2 MPa, the design is confirmed to be safe. This substantial margin indicates that the MDF components are expected to function reliably under anticipated loads, thereby ensuring the mechanism's durability and safety.

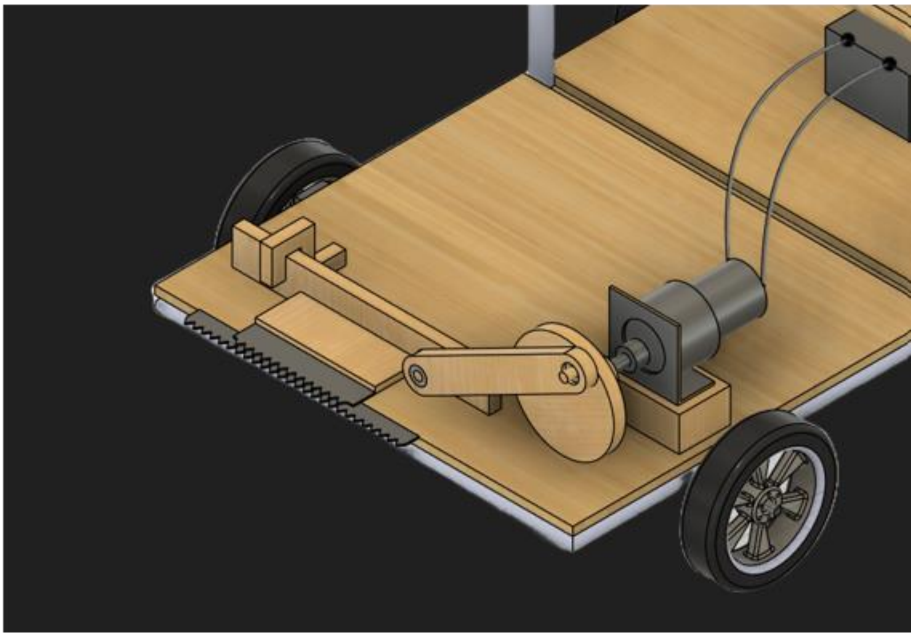


Figure 4 Working Mechanism

The crop harvester represents a pinnacle of agricultural innovation, designed to manage the demanding task of crop harvesting efficiently and effectively. At its core lies a sophisticated interplay of mechanical components, each playing a vital role in the seamless execution of the harvesting process. The harvester's operation begins with its reliance on a robust battery, serving as the powerhouse that fuels its functionality. This battery, charged with stored energy, serves as the lifeblood of the harvester, providing the necessary power to kickstart its operations. The heartbeat of the harvester, however, lies within the geared motor, a marvel of engineering precision. This motor, energized by the battery's output, initiates a cascade of motion by rotating the disc with controlled precision. As the disc whirls into action, its rotational force is transmitted through the connecting rod, a sturdy conduit of power that bridges the gap between the motor and the cutting mechanism. The culmination of this intricate process occurs at the crank, where the transferred power is harnessed to animate the blades with a graceful yet purposeful motion. These blades, meticulously attached to the crank, serve as the harvester's cutting edge, deftly slicing through the dense foliage with surgical precision. With each rhythmic oscillation, the blades carve through the verdant expanse of crops, leaving behind a neatly trimmed trail of harvested produce. It is this harmonious interplay of mechanical ingenuity, powered by the unwavering energy of the battery, that transforms the mundane act of crop harvesting into a choreographed ballet of efficiency and precision, ensuring a bountiful yield for farmers and sustenance for communities.

6 FUTURE SCOPE

The future of sorghum Harvestor in India looks promising with advancements in mechanized harvesting technologies. Innovations such as autonomous harvesters, sustainable practices, and region-specific solutions can enhance efficiency and productivity. Reducing costs and providing financial support will make these technologies accessible to more farmers. Training programs will equip farmers with necessary skills, and integrating digital tools can optimize operations. Increased production will open new market opportunities, and collaborative R&D will drive further advancements. These developments will boost productivity, profitability, and sustainability for Indian sorghum farmers.

7 CONCLUSION

In summary, the design's foundation rests on a thorough consideration of material selection and structural integrity. The Medium Density Fibreboard (MDF) components, carefully chosen for their tensile strength of 18 MPa and compressive strength of 10 MPa, undergo meticulous scrutiny. They are further fortified by a safety factor of 2.5, resulting in a permissible stress value of 7.2 MPa, ensuring a robust and dependable performance under operational stresses.

The framework, comprising a PVC pipe with a diameter of 13 mm, represents a deliberate choice for its standardized dimensions, facilitating ease of procurement and compatibility with other components. This selection is informed by the material's inherent characteristics: lightweight yet durable, corrosion-resistant, and easily manipulable, providing a solid yet manageable base for the mechanism.

Mounting considerations are met with the deployment of plywood, its dimensions meticulously tailored to accommodate the battery and the entire mechanism. Plywood emerges as the optimal choice due to its exceptional strength-to-weight ratio, rendering it capable of withstanding operational stresses while remaining relatively lightweight. Its resilience and cost-effectiveness further bolster its appeal, ensuring long-term stability and viability within budget constraints.The meticulous crafting of the slider-crank mechanism from MDF underscores a commitment to precision engineering. Each component, from the crank to the connecting rod and slider, undergoes laser-cutting to exacting specifications. This method ensures uniformity and consistency, essential for the smooth and efficient operation of the mechanism. The incorporation of plain carbon steel joints enhances durability and wear resistance, safeguarding against mechanical fatigue and ensuring sustained performance over time.

The choice of plastic and rubber wheels reflects a nuanced understanding of operational requirements. Their lightweight composition minimizes the overall load on the mechanism, optimizing efficiency and manoeuvrability. The judicious combination of materials affords the wheels sufficient traction across diverse surfaces, ensuring reliable and seamless movement. In essence, the design harmonizes the intricate interplay of materials, leveraging their respective strengths to create a mechanism of unparalleled efficiency and reliability. Each component is thoughtfully selected and meticulously crafted, culminating in a design poised to redefine standards of performance and durability in its operational context.

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