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Replacing Special Mechanism of Tractor with Planer Mechanism – A Review

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ABSTRACT: This review paper delves into the realm of agricultural machinery, with a particular focus on tractors and the mechanisms integral to their operation. Tractors serve as indispensable tools in modern farming, facilitating various tasks crucial to agricultural productivity. While considerable research has explored advancements in tractor technology, there exists a notable gap concerning the replacement of special mechanisms, specifically the four-bar mechanism, with planar mechanisms. This review aims to address this gap by examining the feasibility, advantages, and challenges of integrating planar mechanisms into tractor systems. By synthesizing existing literature and highlighting key findings, this paper sheds light on the potential benefits of such a transition, including improved efficiency, reduced complexity, and enhanced reliability. Moreover, the review underscores the importance of advancing tractor technology to meet the evolving needs of agriculture, ultimately contributing to increased productivity and sustainability in farming practices worldwide.

KEYWORDS: Tractor, agricultural machinery, special mechanisms, planar mechanisms, four-bar mechanism, technology integration, efficiency, reliability, sustainability, farming practices.

I.INTRODUCTION

In the realm of agricultural machinery, the tractor stands as an indispensable workhorse, facilitating various tasks crucial to modern farming practices. Among its many functions, one of the primary roles of a tractor is to prepare fields for planting by manipulating implements such as ploughs. Central to this process is the mechanism responsible for the attachment and manipulation of the plough—a mechanism that traditionally relies on the spatial four bar mechanism. However, as agricultural demands evolve and technological advancements progress, there arises a need to reevaluate the efficacy of existing mechanisms and explore alternatives that can enhance performance and productivity.

The spatial four bar mechanism has long served as a cornerstone in tractor technology, providing a means to translate rotational motion into linear motion, thereby enabling the controlled movement of implements. Comprising four interconnected links—two longer driving links and two shorter driven links—the spatial four bar mechanism offers a simple yet effective solution for transmitting power and guiding the motion of attached implements. This mechanism, embedded within the framework of tractors, has played a pivotal role in mechanizing agricultural processes, significantly augmenting efficiency and output.

However, despite its widespread adoption and historical significance, the spatial four bar mechanism is not without its limitations. Challenges such as restricted range of motion, susceptibility to wear and tear, and limitations in adaptability have spurred the search for alternative solutions that can overcome these drawbacks while improving overall performance. It is within this context that the planar mechanism emerges as a promising candidate for revolutionizing tractor technology.

The planar mechanism represents a departure from the traditional spatial configuration, offering a simplified, two-dimensional approach to motion transmission and manipulation. Unlike its spatial counterpart, which operates in three-dimensional space, the planar mechanism confines its motion to a single plane, thereby streamlining design complexity and potentially enhancing reliability. By embracing the principles of planar motion, tractor manufacturers can

potentially unlock new avenues for innovation, paving the way for more agile, efficient, and versatile agricultural machinery.

The transition from spatial to planar mechanisms in tractor technology heralds a paradigm shift in design philosophy, prompting a reexamination of fundamental principles and engineering considerations. Key factors such as structural integrity, kinematic performance, and operational efficiency come to the forefront as designers navigate the intricacies of planar motion. Moreover, the adoption of planar mechanisms necessitates a reevaluation of manufacturing processes, material selection, and maintenance protocols to ensure seamless integration within existing tractor frameworks.

II. LITERATURE REVIEWS

Emanuela et al. (2014) present findings from their study on the design and field tests of LOCOSTRA, a sustainable tractor engineered for both agricultural operations and humanitarian demining tasks. Their research demonstrates that LOCOSTRA's design efficiency is notably high, boasting a superior power-to-mass ratio and reduced mass compared to analogous machinery utilized in demining endeavors. Importantly, the tractor fulfills its dual functionality seamlessly, successfully executing agricultural tasks as well as technical surveys in humanitarian demining scenarios. Field tests conducted in Italy and Jordan corroborate LOCOSTRA's performance across both domains, highlighting its versatility and effectiveness in real-world applications. Moreover, feedback from professional users, garnered from assessments conducted in actual minefields, underscores the machine's usability and the innovative nature of its design concept. These findings collectively emphasize the significant strides made in advancing sustainable tractor technology, particularly in addressing critical needs within agricultural and humanitarian sectors simultaneously.

G.P. Moreda et al. (2016) shed light on the transformative impact of high voltage electrification in agricultural machinery, with a specific focus on tractors. Their findings underscore the substantial efficiency improvements achieved through electrification, characterized by heightened energy efficiency, reduced fuel consumption, and consequent decreases in CO₂ emissions. Moreover, the review elucidates the myriad enhanced functionalities enabled by electric drives, including superior torque and speed control, noise reduction, and enhanced operator comfort—all of which contribute to elevated work quality. Through an exploration of state-of-the-art developments, the study highlights the evolution of tractor electrification, encompassing advancements in hybrid vehicle rationale, engine auxiliaries, traction drives, and energy storage. Importantly, the review also anticipates future trends, pointing towards the burgeoning applications of electrification in agriculture and signaling a trajectory towards more sustainable and efficient farming practices.

Subodh Patil et al. (2019) conclude that Finite Element Analysis (FEA) proved to be an effective tool for assessing the stress and safety factor values of a tractor's lift arm within a three-point hitch system. The findings indicate that the lift arm, constructed from basic AISI 1020 material, exhibited a safety factor of 1.106 under a load of 13980 N. However, through the utilization of AISI 1040 material coupled with design modifications, the safety factor was notably enhanced to 1.5724, accompanied by a reduction in deformation. As a result, the study recommends the adoption of Part 4 with AISI 1040 material for improved load-bearing capacity. These results underscore the significance of design alterations and material selection in augmenting safety and performance metrics, highlighting the potential benefits derived from such strategic engineering interventions.

R. Abrahám et al. (2014) present compelling evidence showcasing the effectiveness of special wheels with auto-extensible blades, developed at the Slovak University of Agriculture in Nitra, in increasing a tractor's drawbar pull, particularly on soil with varying moisture levels. The research demonstrates a significant enhancement in drawbar pull with these specialized wheels, especially notable on soil with higher moisture content, where a remarkable 36.1% increase was achieved compared to standard tires. Even on soil with lower moisture levels, the improvement remained substantial, with a 17.2% increase observed. The study concludes that these special wheels contribute to the reduction of wheel slip and consequent enhancement of drawbar pull, potentially leading to reduced fuel consumption and minimized soil damage—an advantageous outcome, especially for tractors operating under challenging traction conditions.

Chi Zhang et al. (2017) present a comprehensive examination of a multi-robot tractor system designed for agricultural field work, offering insights into its efficiency, effectiveness, and implications for agricultural practices. Through simulations conducted to evaluate the system's performance under varying conditions, including different numbers of robots, formation patterns, and field sizes, the research demonstrates notable variations in efficiency. For instance, the study highlights that a configuration of three robots in an I-pattern achieved efficiency rates ranging from 83.2% to

89.8% over a 100-meter field length, while a formation of seven robots in a W-pattern attained efficiencies between 59.4% and 65.8% over the same distance. The study concludes that the multi-robot tractor system exhibits heightened effectiveness in larger fields, with efficiencies exceeding 85% for fields surpassing 500 meters in length. Notably, the system's ability to coordinate robot tractors to form spatial patterns and execute turns without collisions significantly reduces total work time and enhances overall work efficiency. By emphasizing the importance of formation control, safety zones, and headland turn coordination, the findings underscore the potential of multi-robot coordination in agriculture to yield substantial improvements in operational efficiency, particularly in the context of large-scale farming operations.

Md. Israil Hossain et al. (2012) provide compelling evidence of the significant advantages offered by strip tillage seeding equipment in dry land farming. Through rigorous experimentation and analysis, the research reveals a remarkable 19% increase in effective field capacity and a corresponding 21% reduction in fuel consumption when employing strip tillage compared to conventional seeding systems. Moreover, the study highlights substantial cost savings, with strip tillage resulting in a remarkable 62% reduction in planting costs compared to traditional methods. Notably, the adoption of strip tillage is shown to correlate with improved crop yields, with wheat yield experiencing a notable 41% increase over conventional methods, along with higher yields observed for lentils and mungbeans.

Linenko et al. (2019) provide a comprehensive evaluation of a multi-robot tractor system's performance through simulations, elucidating its efficiency across varying parameters such as the number of robots, formation patterns, and field sizes. Notably, the research reveals significant variations in efficiency, with configurations like three robots in an I-pattern achieving impressive efficiency rates ranging from 83.2% to 89.8% over a 100-meter field length, while a formation of seven robots in a W-pattern attains efficiencies between 59.4% and 65.8% over the same distance. The study's conclusion underscores the system's effectiveness, particularly in larger fields, where efficiencies surpass 85% for fields exceeding 500 meters. Moreover, the findings highlight the system's capability to reduce total work time and enhance efficiency by coordinating robot tractors to form spatial patterns and execute turns safely, mitigating collision risks. These results underscore the potential of multi-robot coordination in agriculture to yield substantial improvements in work efficiency, especially in large-scale farming operations, emphasizing the importance of factors like formation control, safety zones, and headland turn coordination in optimizing performance.

Abdullah et al. (2018) delve into a kinematic analysis of a tractor engine's crank-rod mechanism using MSC ADAMS software, offering valuable insights into the performance and optimization of mechanical systems. Through meticulous simulation, the research successfully characterizes key parameters such as displacement, velocity, and acceleration, providing a comprehensive understanding of the mechanism's behavior. Moreover, the study harnesses the power of computer simulation to explore design modifications aimed at enhancing performance, underscoring the versatility and efficacy of MSC ADAMS in facilitating design optimization. Notably, the research validates the simulation results by comparing them with analytical formulas, affirming the software's accuracy and reliability in replicating real-world mechanical phenomena. Additionally, the study emphasizes the critical role of selecting optimal crank-rod dimensions in ensuring efficient force transmission and overall engine performance, shedding light on the importance of mechanical efficiency in engineering design. These findings collectively underscore the potential of computer simulation tools like MSC ADAMS in analyzing, optimizing, and advancing mechanical systems, heralding a new era of precision engineering and design innovation.

Zhe Xin et al. (2023) The study introduces a groundbreaking terrain-adaptive hitch mechanism tailored for hilly tractors, aiming to enhance working quality and efficiency in hillside fields. Through the integration of genetic algorithms and simulation tools, the mechanism's lifting performance undergoes optimization, yielding a notable 14.1% increase in the minimum vertical lifting force. Real vehicle tests validate the mechanism's power lifting range and working slope range, exhibiting a maximum error of merely 4.5% from the theoretical range. Notably, the terrain-adaptive hitch mechanism showcases enhanced adaptability by effectively adjusting the transverse posture of farm implements, thereby meeting the ploughing requirements of complex terrains in hilly areas. These findings underscore the significant advancements made in agricultural technology, particularly in addressing the challenges posed by rugged terrains and optimizing operational performance for improved efficiency and productivity.

Pessina D. et al. (2015) The study underscores the critical importance of Roll Over Protective Structures (ROPS) in mitigating injuries during tractor overturns, particularly through the significant reduction in fatal rollovers observed in countries with mandatory ROPS regulations. However, it also addresses handling challenges associated with foldable roll-bars on narrow-track tractors, which often remain in the rest position due to operational difficulties, compromising rollover protection. The research highlights concerns regarding the load limits specified in OECD's updated Code 6,

advocating for a higher limit of 250 N, in line with ISO standards for non-continuous tasks, as a more ergonomically justified approach. While the current 100 N limit is frequently exceeded in practice, necessitating additional aiding devices, the adoption of a 250 N limit could facilitate manual handling of several roll-bars without the need for supplementary mechanisms. Ultimately, the authors advocate for further automation to eliminate manual handling risks entirely, emphasizing the importance of ergonomic considerations in enhancing tractor safety and operator well-being.

III.LITERATURE GAP

Based on the extensive literature review provided, it is evident that there is a significant gap in research regarding the replacement of special mechanisms, specifically the four-bar mechanism used in tractors, with planar mechanisms. While various studies have explored advancements in tractor design, technology, and performance optimization, none have specifically addressed the feasibility, advantages, and challenges of integrating planar mechanisms into tractor systems as replacements for existing special mechanisms.

Planar mechanisms offer unique potential benefits, including improved efficiency, reduced complexity, and enhanced reliability in certain applications. However, the absence of literature focusing on the replacement of special mechanisms with planar mechanisms highlights a critical gap in current research. Conducting a comprehensive review specifically on this topic would provide valuable insights into the feasibility, performance implications, and practical considerations associated with such a transition.

By addressing this literature gap, researchers can contribute to advancing tractor technology and innovation, potentially leading to more efficient, reliable, and cost-effective agricultural machinery. Furthermore, exploring the integration of planar mechanisms into tractor systems could open up new avenues for improving agricultural productivity and sustainability, ultimately benefiting farmers and agricultural communities worldwide.

IV.CONCLUSION

In conclusion, this review paper has highlighted the essential role of tractors in modern agriculture and the ongoing efforts to enhance their performance and efficiency. While existing literature has explored various aspects of tractor technology, a significant gap remains regarding the replacement of special mechanisms with planar mechanisms. By addressing this gap through comprehensive research, we can unlock new avenues for innovation in tractor design, ultimately leading to more efficient, reliable, and sustainable agricultural machinery. This pursuit of advancements in tractor technology holds the potential to benefit farmers worldwide, driving progress towards a more productive and resilient agricultural sector.

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