ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering | e–ISSN: 2067 – 3809
Tome XVIII [2025] | Fascicule 3 [July – September]

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COMPARATIVE STUDY ON THE EFFICIENCY OF ALTAIR SOFTWARE FOR SIMULATION AND OPTIMIZATION IN AGRICULTURE

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Abstract: The development and implementation of advanced technologies in agriculture have become essential for optimizing processes and increasing production efficiency. Simulation software plays a crucial role in analyzing and improving factors that influence agricultural yield, such as resource use, climatic conditions and optimization of agricultural machinery. This comparative study evaluates the performance of the main Altair software used in the agricultural field, analyzing their ability to model and optimize various agricultural processes. The comparison is based on criteria such as simulation accuracy, ease of use, integration with other technologies and the impact on agricultural management decisions. The results highlight the advantages and limitations of each software, thus providing a solid basis for choosing the most effective simulation solutions for the agricultural sector. By analyzing real–world applications and comparing key performance indicators, this research provides a robust foundation for selecting the most appropriate simulation solutions tailored to the specific needs of the agricultural sector. The findings aim to support engineers, researchers, and agronomists in leveraging digital technologies for smarter, more efficient, and sustainable farming practices.
Keywords: study, Altair, software, simulation, evaluation, agriculture

INTRODUCTION

Agriculture has always been a cornerstone of human civilization, evolving from simple manual labor to a complex, technology–driven industry that feeds billions of people worldwide. As global challenges intensify—ranging from population growth and climate change to land degradation and labor shortages—the need for smarter, more efficient agricultural systems becomes increasingly urgent. Zhao Z. et. al (2024) In response, the agricultural sector is undergoing a technological revolution, integrating tools and practices that once belonged solely to industrial and engineering domains. Among these, simulation and optimization software have emerged as essential instruments in transforming how agricultural operations are planned, executed, and refined. Xi X. et. al. (2023)

Simulation technologies enable researchers, engineers, and agricultural practitioners to create virtual models of real–world systems, allowing for in–depth analysis of variables that influence agricultural outcomes. Shamshiri RR et. al. (2024) Whether it is the layout of irrigation systems, the configuration of machinery, or the impact of climatic changes on crop development, simulation tools provide a risk–free environment to test, optimize, and validate strategies before implementation in the field. This ability not only enhances productivity and efficiency but also reduces the cost and time associated with trial–and–error methods in traditional farming.

Optimization, a closely related concept, goes a step further by identifying the best possible solutions within a set of constraints. In agriculture, this could involve maximizing yield with limited water resources, minimizing fuel consumption in machinery operations, or scheduling planting and harvesting to align with optimal weather conditions. Zainal NN et. al. (2024) By combining simulation with optimization, agricultural stakeholders can make informed, data–driven decisions that balance productivity with sustainability.

Altair, a globally recognized provider of engineering simulation and optimization solutions, has increasingly directed its expertise toward agricultural applications. Its software suite includes powerful tools capable of modeling complex systems, simulating environmental interactions, optimizing mechanical components, and integrating with emerging technologies such as artificial intelligence, machine learning, and Internet of Things (IoT) platforms. Originally developed for use in automotive, aerospace, and manufacturing industries, Altair's tools are now being adapted to meet the unique challenges of agriculture. Jotautienė E. et. al. (2024)

The adoption of Altair software in agriculture reflects a broader trend of cross–sector technological integration. As agricultural machinery becomes more sophisticated and farming operations more automated, the need for advanced simulation platforms becomes evident. Tools like EDEM by Altair, Altair HyperMesh, Altair Inspire, and Altair OptiStruct offer powerful capabilities in areas such as structural analysis, motion simulation, fluid dynamics, and design optimization. When applied to agricultural contexts, these tools can help optimize tractor components, evaluate stress in harvesting equipment, simulate the flow of water in irrigation systems, and model the mechanical behaviour of planting tools. Tran VT. et. al. (2023)

However, despite the clear potential of Altair's software in agriculture, the field remains relatively underexplored in terms of comparative performance analysis. Each tool within the Altair suite has specific strengths and limitations, depending on the nature of the task, user experience level, and integration needs. While some tools may excel in mechanical optimization, others might be better suited for simulating biological or environmental systems. As such, it is essential to conduct a detailed comparative study to assess the effectiveness of each tool across a range of agricultural applications. Li G. et. al. (2023)

This review aims to fill this knowledge gap by providing a comprehensive evaluation of the main Altair software solutions utilized in agriculture. The focus is on understanding their performance based on key criteria such as simulation accuracy, ease of use, compatibility with other digital platforms, and their practical impact on agricultural decision–making. Through this analysis, the study seeks to guide researchers, engineers, and agricultural professionals in selecting the most appropriate tools for their specific operational needs. Guo X. et. al. (2024)

One of the primary considerations in adopting simulation software in agriculture is the accuracy and reliability of the results. Since agricultural environments are influenced by a wide range of dynamic factors—soil composition, weather variability, machinery wear, biological growth cycles—the simulation tools must be capable of capturing this complexity. The ability of Altair software to create high–fidelity models can significantly enhance the precision of predictions and recommendations, making them more actionable and relevant in real–world settings.

Another important criterion is user–friendliness. Many agricultural practitioners may not have formal training in engineering simulation, and overly complex interfaces or workflows can become a barrier to effective use. Altair has made significant strides in recent years to improve the accessibility of its software, offering more intuitive interfaces, pre–built templates, and guided workflows. This technology is critical to expanding its adoption among farmers, agronomists, and agricultural engineers. Zhang Q et. al. (2024)

Interoperability is also a key factor in determining the suitability of simulation software. In modern agriculture, digital systems must work in harmony with a wide array of technologies, including GPS systems, GIS platforms, drone mapping software, sensor networks, and data analytics tools. The ability of Altair software to integrate with these systems enhances its value proposition; enabling users to build comprehensive digital ecosystems that support smarter, more connected farming practices. Pásthy L. et. al. (2024)

This study considers the broader implications of using simulation and optimization tools on agricultural management decisions. When software tools provide clear, quantifiable insights into process performance, they empower users to make more confident and effective decisions. Whether it's optimizing the planting strategy for a new crop, redesigning irrigation infrastructure, or adjusting machinery settings for different field conditions, the insights derived from Altair simulations can lead to better resource utilization, reduced operational costs, and improved environmental outcomes.

2. MATERIALS AND METHODS

This study aims to evaluate the capabilities and practical applications of various Altair software tools within the agricultural sector through a detailed review of existing case studies. The selected case studies illustrate how these advanced simulation and optimization tools are employed to address specific agricultural challenges, optimize machinery design, and improve operational efficiency.

The materials analyzed include documented applications of Altair software such as EDEM, Inspire, OptiStruct, and HyperWorks. Each software tool possesses unique strengths and functionalities that make them suitable for different aspects of agricultural simulation and optimization.

Altair EDEM: Discrete Element Method for Soil and Crop Interaction

Altair EDEM is a specialized simulation software designed for Discrete Element Method (DEM) analysis, which models the behaviour and interaction of granular materials. In the agricultural context, EDEM is instrumental in simulating the complex interactions between agricultural machinery and particulate materials such as soil, seeds, fertilizers, and crop residues. This capability is critical for optimizing the design and operation of equipment that physically interacts with these materials.

One of the core strengths of Altair EDEM lies in its ability to replicate realistic soil dynamics. Soil is a highly heterogeneous and dynamic granular medium, and its interaction with machinery components such as tires, tillage tools, and seeders profoundly affects agricultural productivity and sustainability. Using EDEM, engineers can simulate soil deformation, compaction, and displacement under various operational conditions without the need for costly and time–consuming field trials.

To address common challenges in no–tillage seeding—such as clod formation, poor soil fluidity, and inadequate soil coverage—a novel soil–covering device with integrated soil–closing functionality was designed by Geng Y. et. al. (2023) for a corn no–tillage planter. The device is composed of several key components: a trench opener, share shaft, seed metering device, soil dividing plate, and soil–covering discs.

The soil–covering process is executed in two stages. Initially, finely divided soil is directed over the seed trench using a specially designed soil dividing plate. This is followed by the application of loose soil through the soil–covering discs, ensuring comprehensive and stable coverage.

To optimize the structural and operational parameters of the device, numerical simulations were conducted. These simulations guided the determination of optimal operating conditions, including an operating speed of 6.35 km/h, a soil–covering disc inclination angle of 60°, an opening angle of 70°, and a soil dividing plate inclination angle of 40°.

Performance tests demonstrated that the new device achieved improved uniformity in soil–covering thickness and enhanced stability in seed placement when compared with conventional no–tillage seeding equipment.

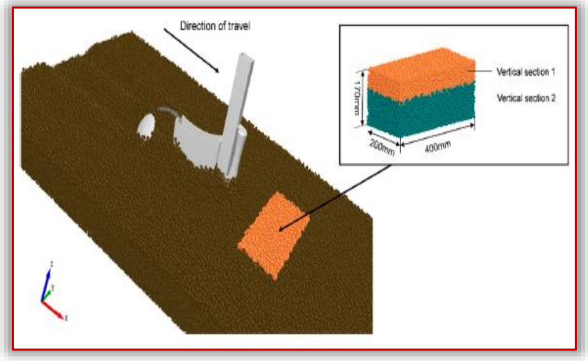

Figure 1 Simulation model of cover device Geng Y. et. al. (2023)

Figure 1 presents the simulation model used to analyse the interaction between the soil–covering device and the soil environment. The model includes the structural representation of the soil–covering device and a trough that simulates field soil conditions. This setup was used to observe and evaluate the dynamic behaviour of soil particles during the operation of the device. The simulation was designed to replicate real–world conditions, enabling detailed visualization of soil movement and distribution. As the soil–covering device traverses the simulated soil trough, the model captures the sequential covering process—first with finely divided soil via the soil dividing plate, followed by loose soil applied by the soil–covering discs. This visual data provided critical insights for optimizing the structural parameters and operational efficiency of the device.

Altair Inspire: Motion Simulation and Structural Optimization

Altair Inspire is a versatile simulation software platform that combines motion simulation and structural analysis to support the design, optimization, and validation of mechanical components. In the agricultural sector, Inspire plays a crucial role in enhancing the performance, durability, and efficiency of machinery components, helping engineers develop innovative solutions tailored to the demanding conditions of farming operations.

One of Inspire's key capabilities is its motion simulation functionality, which enables dynamic analysis of moving parts within agricultural machinery. This feature allows engineers to model the kinematics and kinetics of systems such as tractor linkages, harvesting mechanisms, planting arms, and irrigation equipment. By simulating how these components move and interact under operational loads, users can identify potential issues like excessive stress, interference, or inefficient motion paths early in the design process.

Turan M et. al. (2024) study focused on the development and evaluation of a narrow suspension seat (NSS) aimed at improving vibration isolation performance. The fundamental dynamic equations governing the suspension system were first established to characterize its mechanical behavior. A simulation model of the NSS was then constructed using Altair Inspire software. To ensure the model's validity, results were cross–checked and confirmed through an extensive literature review. The Taguchi method was employed to design simulation cases systematically and to examine the influence of key design parameters on the vibration isolation performance of the NSS. To evaluate the effects of these parameters, signal–to–noise (S/N) ratio analysis and analysis of variance (ANOVA) were conducted. These statistical tools allowed for the identification of significant factors and the determination of optimal design settings.

The results revealed that the spring ratio had a greater impact on vibration isolation performance compared to spring preload. Based on these findings, optimal parameters for the NSS were identified. The optimized suspension seat exhibited superior vibration isolation capabilities in comparison to conventional passive suspension systems.

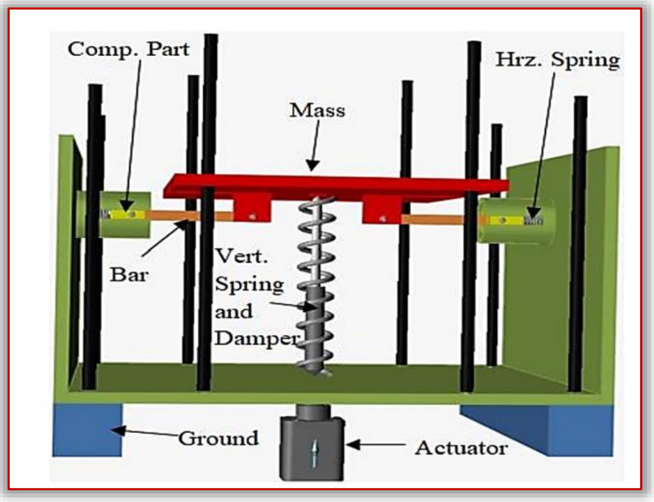

Figure 2. Altair Inspire Model of the redesigned seat suspension
Turan M et. al. (2024)

Figure 2 shows the mechanical model used to evaluate the vibration isolation performance of a suspension seat with a negative stiffness structure (NSS). The model includes a central mass supported by horizontal springs for lateral vibration control and vertical spring–damper units for vertical isolation. A connecting bar maintains alignment, while the system is anchored to a ground base. An actuator beneath the vertical units simulates external forces. This setup enables multi–directional vibration analysis and highlights the benefits of integrating negative stiffness elements.

Altair OptiStruct: Structural Analysis and Topology Optimization

Altair OptiStruct is a powerful finite element analysis (FEA) and structural optimization software widely used in engineering fields, including agriculture, to enhance the durability, performance, and efficiency of equipment. Through advanced simulation techniques, OptiStruct enables agricultural engineers to analyze complex mechanical components and assemblies under realistic loading conditions, optimize their design, and reduce material usage while maintaining or improving structural integrity.

One of the primary strengths of OptiStruct lies in its optimization technology, which includes topology, size, and shape optimization. Topology optimization, in particular, is widely utilized to redesign agricultural equipment components by removing excess material while preserving load–bearing capacity and stiffness. This process helps produce lightweight parts, which are essential for improving fuel efficiency, reducing soil compaction, and enhancing maneuverability in the field.

Perumal S. et. al. (2017) focused on the design optimization of a tractor rear tow hook assembly to enhance performance, reduce weight and cost, and improve serviceability. The objective was to address key concerns raised by customers, such as excessive component weight, assembly complexity, and limited accessibility to fasteners. A finite element model (FEM) of the tow hook assembly was developed using *HyperMesh* to simulate various loading conditions reflective of real–world tractor operations. Size optimization techniques were applied using the *OptiStruct* solver to reduce material usage while maintaining structural integrity. This process led to a 34.5% reduction in overall weight without compromising durability. The optimized design was validated through physical durability tests, which confirmed the absence of failure and achieved a strain correlation of over 84% with simulation predictions. In parallel, user feedback was incorporated into the redesign process to address ergonomic and maintenance–related challenges. The improved tow hook assembly featured a simplified geometry, fewer parts, and enhanced accessibility, contributing to significantly improved serviceability. The optimization also resulted in a 16.8% cost reduction, offering considerable annual savings. Looking ahead, further refinement of the tow hook system is planned using stochastic analysis methods to explore additional performance gains and design robustness under uncertain operating conditions.

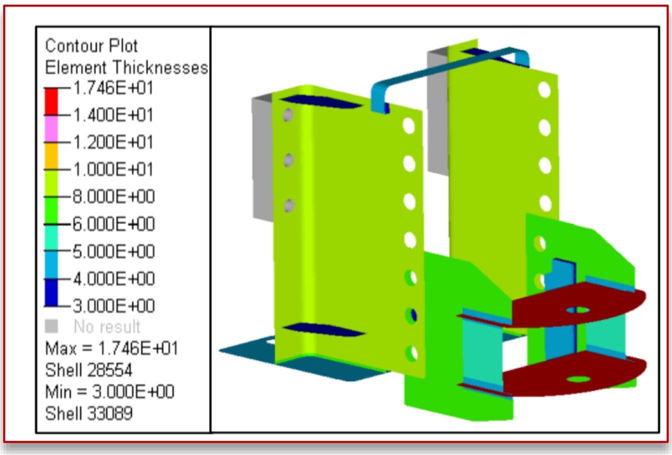

Figure 3. Altair OptiStruct tow hook system optimization
Perumal S. et. al. (2017)

Figure 3 shows the thickness changes in key components of the tow hook assembly before and after optimization. Significant reductions were made to improve weight and performance: the base support plate (10.0 mm to 4.0 mm), stiffener plate (10.0 mm to 3.0 mm), support plate (8.0 mm to 4.0 mm), L–plate (10.0 mm to 3.0 mm), tow hook side support plate (10.0 mm to 6.0 mm), and vertical support plate (16.0 mm to 5.0 mm). The side support plate remained unchanged at 8.0 mm. These adjustments led to a 34.5% total weight reduction.

Altair HyperMesh: Comprehensive Simulation Suite

Altair HyperMesh is a comprehensive suite of simulation, modeling, visualization, and analysis tools designed to support engineering workflows across diverse industries, including agriculture. Its versatile platform enables agricultural machinery designers and engineers to efficiently develop, test, and refine components and systems, ensuring robust performance, enhanced durability, and optimized functionality.

One of the core strengths of HyperWorks is its advanced pre–processing and meshing capabilities, which enable the creation of highly detailed and accurate finite element models of agricultural equipment.

This accuracy is vital in capturing the intricate geometries of machinery components and assemblies, such as gearboxes, hydraulic systems, chassis frames, and tillage implements. Precise modeling allows for realistic simulations of stress distribution, deformation, and potential failure points, thereby guiding designers in making informed decisions early in the development process.

Karpat F. et. al. (2018) focused on the design, simulation, and physical testing of Rollover Protective Structures (ROPS) for agricultural and construction machinery, specifically frame–type ROPS mounted on the front of orchard tractors. Two testing methods were employed: a dynamic method using pendulum impact tests and a static method applying controlled loads to simulate rollover scenarios. Finite element models were developed using *ALTAIR/ HyperWorks*, and simulations were conducted with *RADIOSS* software.

The ROPS were made of Fe 360 C and Fe 510 D structural steels, selected for their specific yield and tensile strength properties. Simulation results were compared with physical test data, showing a high level of correlation and validating the design approach. This integration of simulation and physical testing enabled accurate prediction of structural behavior during rollovers, ensuring compliance with international standards (OECD, EC, ISO) and reducing the need for multiple physical prototypes.

Figure 4 illustrates the loading sequence applied to the Rollover Protective Structure (ROPS) during testing, beginning with rear longitudinal loading that simulates rearward overturning through the application of a forward–directed force. This is followed by the first vertical crush, where a vertical load is applied to the top of the structure to assess its resistance to crushing.

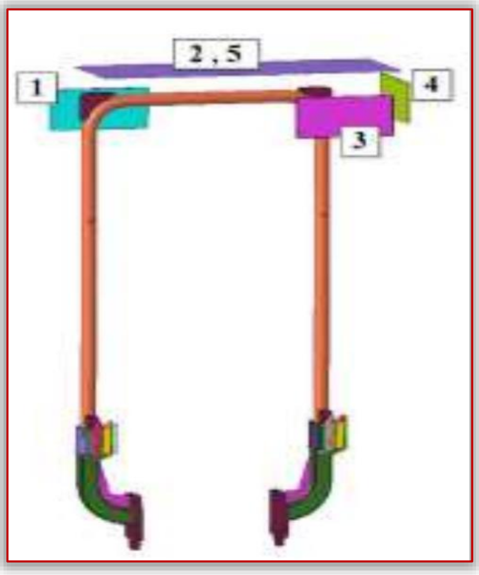

Figure 4. Altair Hyperworks ROPS loading sequence
Karpat F. et. al. (2018)

Next, front longitudinal loading is applied in the backward direction to simulate forward overturning forces. Subsequently, side loading introduces lateral forces to evaluate the structure's performance during sideways overturning, which is critical for maintaining the operator's clearance zone. Finally, a second vertical crush is performed to ensure the ROPS maintains structural integrity after cumulative loading.

3. RESULTS

This section presents a series of case studies showcasing the application and validation of Altair's simulation software suite—EDEM, Inspire, OptiStruct, and HyperMesh—in engineering analysis and design optimization. Each case study integrates simulation results with experimental data, demonstrating the accuracy, reliability, and practical value of these tools in predicting real–world performance and guiding design improvements.

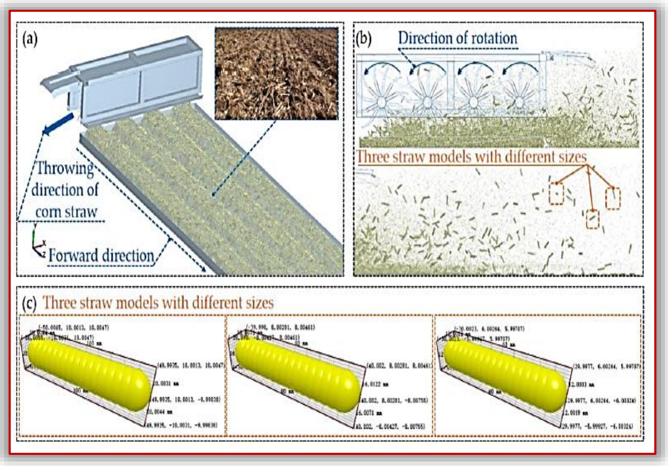

Figure 5. EDEM soil tank simulation [Hou S. et. al. (2022)]

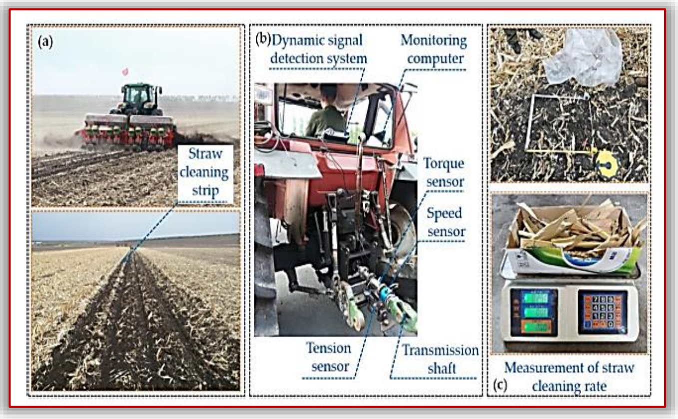

Figure 6. Field test program [Hou S. et. al. (2022)]

The virtual soil tank model used in the simulation is shown in Figure 5 (a), featuring dimensions of 10,000 mm by 2,600 mm with a soil layer height of 150 mm. Figure 5 (b) illustrates the simulation process, highlighting the interaction between the straw–clearing device and the soil–straw mixture. The corn straw model, depicted in Figure 5 (c), is composed of spherical particles arranged to realistically represent the morphology of actual corn straw.

The field test program is detailed in Figure 6, where Figure 6 (a) presents the test environment and procedure conducted in Heilongjiang Province, China, including specific soil and straw conditions. Figure 6 (b) shows the setup of measuring equipment, encompassing sensors and data acquisition systems. Finally, Figure 6 (c) demonstrates the method for measuring the straw–cleaning rate, emphasizing the evaluation technique used to assess the performance of the straw–clearing device.

Figures 7 and 8 illustrate the design and optimization of a logging tractor boom. Figure 7 presents the parameterized model of the boom structure, which is essential for supporting the blade during logging operations. The model was developed using a parameterization–based approach, allowing for the adjustment of key geometric variables to generate multiple design variants. This method enhances design flexibility and supports the development of a customizable product line tailored to different operational requirements. The figure also details the main structural components and their interrelationships, providing insight into how parameter changes influence the overall assembly.

Figure 7. Model of logging boom tractor structure [Dolmatov S. et. al. (2024)]

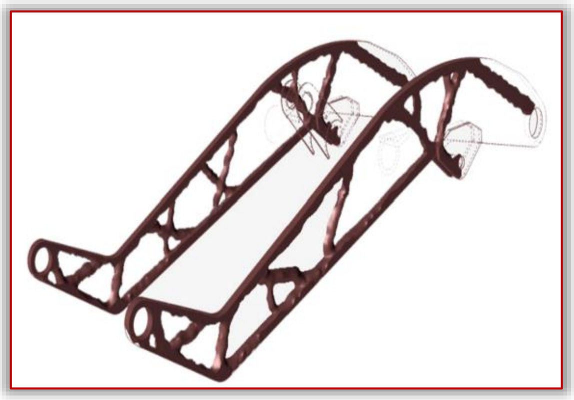

Figure 8. Topological optimization using the Altair Inspire [Dolmatov S. et. al. (2024)]

Figure 8 displays the results of topological optimization conducted using the Altair Inspire CAE platform. The optimization process aimed to reduce the boom's weight while maintaining its structural integrity and performance under expected loading conditions. Material distribution was refined by removing low–stress regions and reinforcing critical load–bearing zones. The resulting design demonstrates a more efficient structure with an improved strength–to–weight ratio. These optimizations not only contribute to material savings and cost reduction but also enhance the dynamic and operational performance of the boom.

Figures 9 and 10 present the simulation results and the experimental setup related to the vibration analysis of a gearbox system.

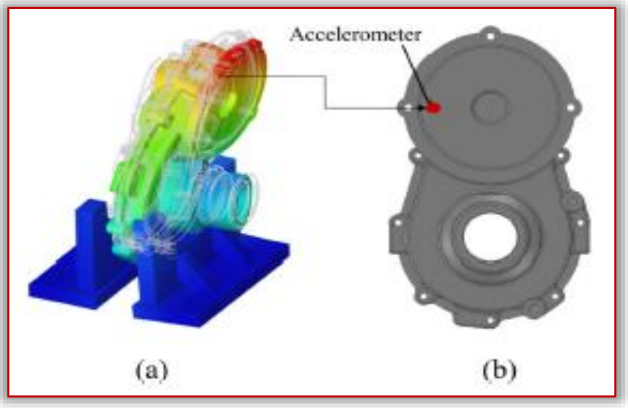

Figure 9. 3D Model of the gear system (a) & Accelerometer position (b) [Kim BS. Et. al. (2024)]

Figure 9 presents the results of the modal analysis performed on the gearbox housing. The figure displays the mode shape of the housing at a specific natural frequency, revealing areas of maximum deformation. It also indicates the position of the accelerometer used during the run–up test. The modal analysis was essential for identifying the optimal accelerometer placement, ensuring that vibration measurements captured the most significant structural responses. Together, these results provided a comprehensive understanding of the gearbox's dynamic behavior, facilitating improved diagnostic accuracy and structural refinement.

Figure 10 shows the physical layout of the gearbox test setup, which includes key components such as the gearbox under investigation, a motor dynamometer to control the input shaft's rotational speed, and an inverter to regulate the dynamometer. A torquemeter is used to measure the load on the output shaft, while a flexible coupling ensures efficient power transmission between the input dynamometer, gearbox, and output dynamometer. This setup was designed to evaluate both the vibration and acoustic characteristics of the gearbox under operational conditions.

Figure 10. Gearbox test [Kim BS. Et. al. (2024)]

Figures 11 and 12 present the simulation and experimental results of lateral loading applied to the Rollover Protective Structure (ROPS) of the tractor cabin.

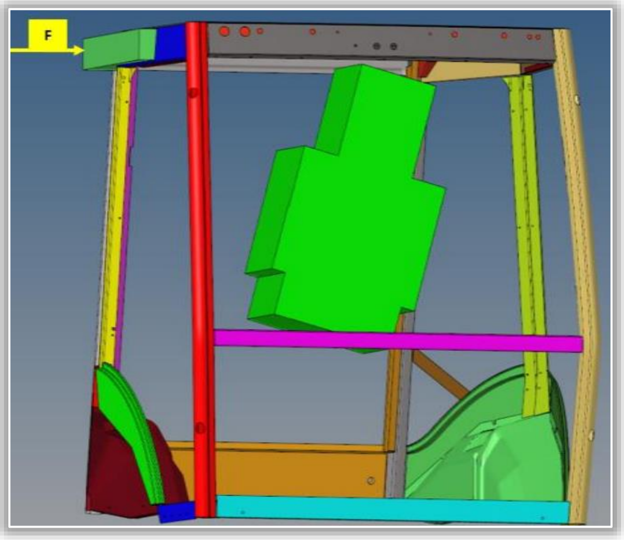

Figure 11. Lateral Loading (FEM) with Altair HyperWorks [Karakulak SS et. al. (2022)]

Figure 12. Lateral loading (before & after test) [Karakulak SS et. al. (2022)]

Figure 11 illustrates the finite element analysis (FEA) conducted to evaluate the structural response under lateral force. In this simulation, a force of 600,066 N was applied, initially causing a displacement of 250 mm. The loading continued until the kinetic energy reached 125,001 J, resulting in a total displacement of 281 mm.

Throughout the simulation, no intrusion into the Deflection Limiting Volume (DLV) was observed, indicating that the ROPS maintained its protective function.

Figure 12 complements the simulation results by showing the physical testing of the ROPS under the same lateral loading conditions. The figure contrasts the structural state of the ROPS before and after testing.

The deformation observed post–test aligns with the simulation outcomes, and, critically, no penetration into the DLV was detected. This confirms the structural integrity of the ROPS under lateral impact and validates the accuracy of the FEM model used in the simulation.

4. DISCUSSION

The simulation and optimization of agricultural processes represent a crucial stage in advancing modern farming efficiency. The effectiveness of these operations is influenced by factors such as the design of equipment, the integration of smart technologies, and the degree of digital mechanization employed. This study highlights that the use of advanced Altair software tools—such as EDEM, Inspire, OptiStruct, and HyperWorks—significantly enhances productivity and operational reliability. By enabling precise modeling, virtual testing, and data–driven optimization, these technologies offer a viable solution to the pressing challenges faced by today's agricultural sector.

Efficiency of Simulation and Optimization Tools in Agriculture

Efficient management and mechanization of agricultural operations are essential for optimizing productivity and sustainability in modern farming. Advanced simulation and optimization software, such as those offered by Altair, play a pivotal role in enhancing the design and performance of agricultural machinery and processes. Unlike traditional trial–and–error methods, these tools enable precise virtual testing and optimization, significantly reducing time and resource consumption. For instance, Altair EDEM facilitates the realistic simulation of interactions between agricultural equipment and granular materials such as soil and seeds, allowing engineers to optimize machinery settings for improved planting efficiency and seed distribution.

Impact of Altair Software on Agricultural Machinery and Operations

The adoption of Altair's suite—comprising EDEM, Inspire, OptiStruct, and HyperWorks—helps streamline the design and operation of agricultural machinery. Altair Inspire's motion simulation and structural analysis capabilities support the development of components that are both robust and efficient, minimizing mechanical failures during critical operations like planting and harvesting. Altair OptiStruct's optimization algorithms enhance the durability and energy efficiency of equipment by refining structural elements, leading to lighter and more resilient machinery. Meanwhile, Altair HyperWorks provides a comprehensive environment for modeling, visualization, and analysis, supporting the end–to–end design process. These tools collectively contribute to more uniform soil preparation, precise planting, and reduced wear on equipment, all of which boost overall operational productivity.

Sustainability and Environmental Benefits

Simulation–driven optimization supports sustainability goals by enabling more efficient use of inputs such as fuel, water, and seeds. For example, by simulating irrigation systems or seed dispersal patterns, Altair software can reduce waste and improve resource allocation. Additionally, optimized machinery components require less maintenance and consume less energy, leading to lower carbon emissions over their operational lifespan. The ability to model soil–machine interactions with tools like EDEM also aids in minimizing soil compaction and preserving soil health, which are critical for long–term agricultural productivity.

Adaptation to Climate & Terrain Challenges

The dynamic nature of agricultural environments—characterized by varying soil types, weather conditions, and terrain—poses significant challenges for mechanized operations. Altair's simulation platforms allow for comprehensive testing and adaptation of machinery and processes to these variable conditions. For instance, simulating the performance of planting equipment on uneven or compacted soils helps optimize designs that perform reliably across diverse fields. This capability is especially valuable in regions facing climate variability, where rapid and flexible responses are necessary to maintain crop yields.

Integration of Advanced Technologies

Mechanized planting not only improves efficiency but also contributes to environmental protection. The use of modern equipment reduces the ecological impact by minimizing carbon emissions and reducing the use of fossil fuels compared to traditional planting methods that rely on manual labor or less efficient equipment. Additionally, mechanized machines can be equipped with technologies that reduce soil compaction and minimize damage to local ecosystems.

Altair's integration with emerging technologies such as artificial intelligence, machine learning, and IoT platforms further enhances the potential for smart agriculture. Simulation models can be continuously refined using real–time data collected from sensors and drones, enabling dynamic optimization of machinery and field operations. This level of digital integration facilitates data–driven decision–making, leading to improved planting strategies, irrigation schedules, and equipment maintenance plans.

Challenges and Limitations

Despite their advantages, implementing advanced simulation and optimization software in agriculture requires significant upfront investment in technology and training. The complexity of some tools may pose usability challenges for farmers and agronomists unfamiliar with engineering software. However, ongoing efforts by Altair to improve user interfaces and provide guided workflows are helping access to these powerful tools. Additionally, combining simulation insights with field experience remains critical to ensure practical applicability and success.

Economic and Long–Term Benefits

Although initial costs for adopting simulation software and optimized machinery design can be substantial, the long–term benefits often outweigh these investments. Increased machinery efficiency, reduced resource consumption, and enhanced crop yields contribute to lowering operational costs over time. Moreover, the accelerated development cycles enabled by virtual prototyping shorten time–to–market for new agricultural technologies, supporting faster innovation and sustainable growth within the sector.

5. CONCLUSIONS

The study demonstrates that the application of Altair's suite of simulation and optimization software offers a highly effective approach to enhancing agricultural processes and machinery design. Tools such as Altair EDEM, Inspire, OptiStruct, and HyperWorks collectively improve the efficiency and precision of agricultural operations by enabling detailed modeling, motion simulation, structural optimization, and granular material interaction analysis. The use of these advanced technologies increases productivity, reduces resource waste, and supports the development of more durable and sustainable agricultural equipment. In the current context of rising global food demand and growing environmental concerns, the adoption of such modern simulation tools is essential for driving innovation, optimizing resource use, and ensuring long–term sustainability in agriculture.

Acknowledgement(s):

The results were obtained with the support of MCID through the NUCLEU Program, contract no. 9N/ 01.01.2023 project PN 23 04 02 03 "Innovative technology for covering the interval between the rows of vines and fruit trees to avoid degradation of the soil structure".

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ISSN: 2067–3809