Design and Performance Testing of Cranes Lifting Agricultural Equipment and Machinery

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ABSTRACT

Handling agricultural machinery and equipment with significant mass requires lifting aids that can enhance efficiency and reduce manual labor. This study aimed to design and test the performance of a lifting crane intended to assist in the lifting and relocation of agricultural machinery. The research involved design, fabrication, and performance testing using incremental loads of 45, 65, 100, 150, 200, 215, and 250 kg. Testing parameters included load mass, lifting time, lifting height, and the structural condition of the crane under load. The results showed that the crane measured 208 cm in length, 87 cm in width, and 195 cm in height, utilizing an HGS-B Micro Electric Rope Hoist motor for the lifting system. Lifting time increased from 7.35 seconds at a 45 kg load to 10.90 seconds at a 250 kg load, while lifting height decreased from 140 cm to 128 cm. Although the crane was capable of lifting loads up to 250 kg, structural bending in the legs began to occur within the 215-250 kg load range. Consequently, the recommended maximum operating load is 200 kg. The study concludes that the designed crane has the potential to serve as a lifting and handling aid for agricultural machinery, provided that load limits and structural integrity are taken into account.

Keywords: *crane, agricultural tools and machinery, lifting, load, performance*

I. INTRODUCTION

Handling agricultural tools, machinery, and components of significant mass requires lifting aids, as manual handling is limited by constraints regarding physical effort, efficiency, and workplace safety. While lifting equipment is used to transfer loads between positions, portable cranes offer the advantage of mobility, allowing them to be positioned according to the location of the object being lifted. Khori et al. (2021) demonstrated that portable cranes can lift and move components that are difficult to handle manually, thereby helping to reduce the risk of accidents associated with direct load handling. Furthermore, the use of cranes accelerates material transfer processes–previously performed using manual pulleys–thereby enhancing work efficiency and reducing the potential for workplace accidents (Siregar, Lubis, & Usman, 2018).

Advancements in portable crane technology demonstrate that the design of lifting equipment requires an integrated approach involving the frame, drive system, transmission mechanism, lifting cable or sling, and mobility system. Siregar et al. (2018) developed a crane featuring a motor that drives a drum via a gearbox transmission and uses a steel cable for lifting, with a design that allows for assembly and disassembly. Meanwhile, Kadriadi et al. (2024) designed a portable crane utilizing an electric motor, gearbox, and sling, while incorporating a safety factor to determine the structure's load-bearing capacity. The inclusion of wheels enables the portable crane to be moved within the work environment, offering greater flexibility compared to stationary lifting equipment.

Structural capacity and safety are critical factors in determining crane performance. The lifting capability of the drive system alone cannot serve as the sole basis for establishing the equipment's operating limits, as the stability of the frame and supporting components must also be considered. Kadriadi et al. (2024) incorporated a safety factor into the design of a portable crane to ensure that key components could withstand the intended loads. Furthermore, Siregar et al. (2018) highlighted that major components–such as steel cables, drums, hooks, and drive motors–are vital to crane design due to their direct role in the lifting process. Consequently, performance testing is essential to assess the equipment's actual capabilities and verify that the established operating limits align with the structural integrity and the characteristics of the lifting system.

In the context of agricultural machinery and equipment, the need for lifting aids is increasingly important, as machine components vary in mass and dimensions and are not always easily moved by hand. Portable cranes offer a solution to assist with the maintenance, repair, installation, and relocation of agricultural machinery components. The use of a portable crane also enhances operational flexibility, as the unit can be positioned to suit the specific object being lifted (Kadriadi, Wirakusuma, Opu, & Alfian, 2024). Consequently, there is a need for a lifting device featuring a simple design and high mobility that is capable of handling the loads required for agricultural machinery operations.

Based on this need, this study was conducted to design and fabricate a crane for lifting agricultural machinery and implements–equipment that was previously unavailable–and to evaluate its performance under varying loads. Testing involved monitoring load mass, lifting time, lifting height, and the structural condition of the crane during loading. This approach was necessary to determine the crane's actual capabilities and establish working load limits based on test results, rather than relying solely on the lifting motor's nominal capacity. The study aimed to design and test the crane's performance and to determine the recommended working load based on lifting response and structural integrity. The findings are expected to yield an assistive technology that supports the lifting and handling of agricultural machinery and implements more effectively and safely.

II. MATERIALS AND METHOD

2.1 Time and Location of the Study

The research was conducted over a period of two years at the Agricultural Machinery and Equipment Laboratory, Gorontalo Polytechnic. It encompassed the stages of design, fabrication, and performance testing of a crane for lifting agricultural tools and machinery.

2.2 Tools and Materials

The materials used to construct the crane include hollow steel sections, rubber wheels, steel cables, and an electric motor. The main frame is fabricated from 8x4 cm hollow steel, while the lifting system utilizes an HGS-B Micro Electric Rope Hoist with a capacity of 125/250 kg. The equipment employed during the manufacturing process includes a drilling machine and an electric welding machine.

2.3 Crane Design and Manufacturing

Crane design is carried out by considering the function of the tool as an auxiliary means for lifting and moving agricultural tools and machines that have a relatively large mass. The design consists of several main components, namely poles, swing arms, rollers, suspension, electric motors, steel ropes and wheels. The mast and swing arm serve as the main load-bearing structure, while the rollers and steel ropes form the lifting mechanism. The electric motor is used as a power source to drive the lifting system, while the wheels function to support the crane's mobility.

The crane was constructed according to a predetermined design through processes involving cutting, drilling, welding, and component assembly. The dimensions of the finished crane include a leg frame length of 150 cm, a swing arm length of 120 cm, a front leg width of 87 cm, a rear leg width of 80 cm, and a total height of 195 cm. The main structure utilizes 8 x 4 cm hollow steel sections.

2.4 Crane Performance Testing

Testing was conducted to determine the crane's load-lifting capability across various load levels. Test loads were applied incrementally: 45, 65, 100, 150, 200, 215, and 250 kg. At each load level, the time required to lift the load and the lifting height achieved were recorded. In addition to these parameters, the physical condition of the crane structure was monitored throughout the test to detect any changes or deformation resulting from the load. Testing proceeded up to a maximum load of 250 kg to establish the crane's lifting capacity limit.

2.5 Testing Parameters

The performance parameters observed include:

1. Load mass (kg), i.e., the mass of the object being lifted by the crane.
2. Hoisting time (s): the time required for the crane to lift the load from the initial position to the testing position.
3. Lifting height (cm), i.e., the height reached by the load during the lifting process.
4. Condition of the crane structure, particularly deformation or bending of the crane legs while under load.

The test data are used to determine the relationship between the increase in load mass and the crane's lifting time and capacity. The observations are then presented in a table to facilitate the evaluation of the equipment's performance.

2.6 Data Analysis

Crane performance is analyzed based on the equipment's capability to lift various applied load levels. Increases in load are compared against changes in lifting time and height to determine the equipment's response to loading. Additionally, the structural condition of the crane is taken into account when determining the recommended operating load.

III. RESULTS AND DISCUSSION

3.1 Crane Design Results

The design process resulted in a crane intended to assist in lifting and moving agricultural tools, machinery, and materials of significant mass. The crane measures 208 cm in length, 87 cm in width, and 195 cm in height, featuring a main structure constructed from 8x4 cm hollow steel sections. Its lifting system utilizes an HGS-B Micro Electric Rope Hoist with a capacity of 125/250 kg, while wheels are incorporated to facilitate mobility. This design aligns with the work of Khori et al., who developed a portable crane featuring a winch mechanism, wire rope, and wheels to support the transport of loads up to 150 kg (Khori, Mahyoeddin, & Septe, 2021). Furthermore, the use of an electric hoist system is consistent with findings by Muhammad et al. (2025), which demonstrate that a combination of a hoist motor, frame, boom arm, and counterbalancing system can serve as an alternative lifting solution for confined workspaces.

3.2 Crane Performance Test Results

Testing was conducted using incremental loads of 45, 65, 100, 150, 200, 215, and 250 kg to determine the crane's response to increasing loads (Table 1). The test results show that the lifting time increased from 7.35 seconds at a load of 45 kg to 10.90 seconds at a load of 250 kg, while the lifting heights were 140 cm and 128 cm, respectively. This increase in time indicates that the rise in load mass affects the response of the lifting system. A similar trend was observed in tests of other lifting devices, where increased load mass resulted in longer operation times. Thus, lifting time can serve as an indicator for evaluating the crane's performance response to load variations.

Table 1. Crane Performance Test Results

No	Testing	Weight of Sample (kg)	Time (s)	High (cm)
1	1	45	7.35	140
2	2	65	7.40	139
3	3	100	7.75	138
4	4	150	8.60	136
5	5	200	8.82	134
6	6	215	9.10	131
7	7	250	10.90	128
Averages		144.4	8.56	1.714

3.3 Effect of Load on Lifting Time

Increasing the load mass resulted in a trend of longer lifting times: rising from 7.35 seconds at 45 kg to 7.40, 7.75, 8.60, 8.82, 9.10, and 10.90 seconds for loads of 65, 100, 150, 200, 215, and 250 kg, respectively. Thus, increasing the load from 45 kg to 250 kg extended the lifting time by 3.55 seconds, or approximately 48.3%. This pattern indicates that the system requires more time as the lifted mass increases, because a heavier load places greater operational demands on the drive system and lifting mechanism. These findings align with portable crane design principles, which dictate that the selection of the motor and lifting components must be matched to the intended maximum load (Khori, Mahyoeddin, & Septe, 2021). Molnar et al. (2021) also emphasize the importance of matching the lifting motor's power to the load capacity to ensure the crane system's performance and reliability.

3.4 Evaluation of Maximum Load and Structural Stability

Although the crane developed in the study was capable of lifting loads of up to 250 kg, observations revealed bending in the crane's legs when subjected to loads between 215 kg and 250 kg. This indicates that the motor's lifting capacity cannot serve as the sole criterion for determining the crane's operating capacity, as structural stability and strength must also be taken into account. This finding is supported by Muhammad et al. (2025), who observed that while the mini-crane could lift loads exceeding 200 kg, it began to exhibit instability and component deformation; consequently, the recommended capacity was limited to 200 kg. Their research further demonstrated that increasing the load could lead to shaft buckling, deformation of connecting elements, and reduced structural stability as the load approached or exceeded the design capacity.

Based on these results, 200 kg is more appropriately designated as the recommended maximum workload, whereas 250 kg represents the maximum load successfully tested. This limit corresponds to 80% of the maximum test load, thereby establishing a more conservative operating limit than the load level at which deformation begins to occur. This approach aligns with the research of Muhammad et al. (2025), which establishes recommended limits based on structural condition rather than solely on the equipment's lifting capacity. Consequently, evaluating crane performance requires the simultaneous consideration of lifting capacity, operating time, stability, and the equipment's structural condition.

3.5 Implications for the Use of Agricultural Tools and Machinery

The designed crane has the potential to serve as an aid in lifting and moving agricultural machinery and equipment, particularly when component mass makes manual handling difficult. The use of an electric hoist mechanism and a mobile structure offer the opportunity to reduce manual labor requirements while enhancing operational efficiency. Previous developments in portable cranes have demonstrated that systems utilizing winches, wire ropes, and wheels provide a solution for moving materials that are difficult to handle manually (Khori, Mahyoeddin, & Septe, 2021). Muhammad et al. (2025) reported that electric hoist-based mini cranes can improve efficiency and workplace safety in space-constrained environments. In the context of agricultural machinery, these characteristics present opportunities for application in the maintenance, repair, installation, and relocation of machine components.

Safety is also a primary consideration in crane operations. Recent studies on crane operational safety indicate that crane components, lifting devices, and slings are critical factors influencing the level of operational risk. Therefore, the condition of

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the frame, wire ropes, hooks, connections, and lifting components must be inspected prior to operation. Preliminary inspections and trial lifts are also recommended to verify equipment integrity and lifting capacity suitability before applying the working load (Zhong, Chen, Antwi-Afari, Bao, & Chen, 2025).

3.6 Crane Performance Synthesis

Overall, the designed crane was capable of lifting all test loads up to 250 kg, with lifting times increasing from 7.35 to 10.90 seconds as the load increased. However, the bending of the legs observed at loads of 215–250 kg indicates a discrepancy between the motor's lifting capacity and the crane's structural limits. These findings align with research by Muhammad et al. (2025), demonstrating that a higher lifting capacity does not automatically mean a load is suitable for operational use. Based on lifting time responses and structural integrity, a load of 200 kg was established as the recommended maximum working load, while the 250 kg load served solely as a limit for testing purposes. These results indicate the crane's potential as an assistive technology for lifting agricultural tools and machinery, provided that operations adhere to load limits and structural constraints, and that components are inspected prior to use.

IV. CONCLUSION

The designed crane is capable of lifting loads of up to 250 kg; lifting times increased from 7.35 seconds for a 45 kg load to 10.90 seconds for a 250 kg load, demonstrating the impact of load weight on lifting performance. Although the crane can lift 250 kg, the bending observed in the crane's legs at loads between 215 kg and 250 kg indicates a distinction between lifting capacity and structural limits; consequently, 200 kg has been established as the recommended maximum working load. The crane has potential application as an aid for lifting and moving agricultural tools and machinery, provided that operations adhere to load limits and structural integrity standards, and that components are inspected prior to use.

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