Design of a mobile mini crane for loading to truck to reduce damage to fresh fruit loans (FFB) during transport

by Ahmad Saiful Haqqi

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 22, No. 1, p. 11-19, 2023

RESEARCH PAPER

OPEN ACCESS

Design of a mobile mini crane for loading to truck to reduce damage to fresh fruit loans (FFB) during transport

Agung Cahyo Legowo*[1], Arief RM Akbar[1], Abdul Ghofur[1], Hermantoro[2]

[1]*Faculty of Agriculture, University of Lambung Mangkurat, Indonesia*

[2]*Faculty of Agricultural Technology of INSTIPER Yogyakarta, Indonesia*

Article published on January 10, 2023

Key words: Transportation equipment, Mobile mini crane, Fresh fruit bunches, Palm oil, Ergonomics, Efficiency, Effectiveness of sustainable transportation management

Abstract

The design of the Mobile Mini Crane (MMC) prototype begins with the collection and testing of materials to make the crane frame. The motor used is a cargo motor manufactured viar Karya 300, and uses a 14 HP diesel engine which is used to run the hydraulic system. The prototype was tested by means of a test bench, net capacity test and field test. The MMC prototype can carry a load of fresh fruit bunches (FFB) with a max capacity of 400kg/lift, and from an economic perspective, MMC's operational costs are Rp. 20.95,-/kg whereas when compared with manual labor it is Rp. 25,-/Kg. and from the statistical test results, the results of the analysis showed that the amount of FFB lifted was not different but the transportation time was different, the average manual FFB transport was 6,164 (1.7 minutes) per TPH while with MMC it was 4,988 (1,7 minutes). 3 minutes) and the average lifting weight manually is 172kg and using MMC 234kg. besides that it also minimizes work accidents, speeds up the loading of FFB onto trucksand reduce FFB damage during transport. Ergonomically it is able to reduce the risk of work accidents and from an economic point of view it is very effective and efficient.

* **Corresponding Author:** Agung Cahyo Legowo ✉ agung@ulm.ac.id

Introduction

In 2016, the absorption capacity of workers in Indonesian oil palm plantations employed 16 million people to work on new and active oil palm lands (Ishak *et al*., 2017). Massive absorption of labor is needed for the process of harvesting palm fruit. The increase in labor wages issued by the industry becomes bloated during the harvest season (Chrisendo, Siregar, and Qaim 2021). The need for labor for fruit evacuation (harvesting and transportation) of palm fruit is increasingly difficult to obtain. In addition, the use of manual tools to evacuate the fruit requires more energy because of the weight of the palm fruit, which is burdensome for workers and can also result in damage to the fruit. (Lim *et al*., 2021; Muhammad *et al*., 2015). To overcome this, it is necessary to make a palm fruit evacuation tool that can relieve workers. One of the tools/machines that can ease the work of fruit evacuation is a crane. The modified crane development innovation makes it easier to evacuate the fruit when it is harvested and transfer it to the truck from the collection point (Aljawadi *et al*., 2021). This solution can overcome the problem of yield management and transportation of oil palm in plantations in maintaining post-harvest quality (Abd Rahim *et al*., 2020).

Crane is one type of material transfer tool that can move materials in a vertical direction or a combination of vertical and horizontal. Cranes are used to lift cargo vertically, hold it when needed, and lower cargo to a predetermined place by means of luffing, slewing and traveling mechanisms. (Chwastek 2020; Wu *et al*., 2010). Based on the direction of movement of cranes, there are types of mobile cranes and stationary cranes (Kalwasiński 2018). Crane cars can be moved to where they are needed (Sun and Kleeberger 2003). In general, crane cars are used in the manufacturing industry or factories to move goods in large quantities. However, the Mobile Mini Crane from the Mini Truck and Mini Tractor modifications is very difficult to use in field movements, especially in narrow plantation areas. So that the modification of the Crane function can be implemented in overcoming agricultural problems.

Selection of a haulage motor for the type of transportation that is suitable for limited field terrain and qualified power to lift the load of crops. The size of the CC (Cubic Centimeter) or the engine capacity of a transport motorbike tends to be lower than that of a car (Pfaffenbichler and Circella 2009). So that the consumption of fossil fuels needed on transport motorbikes is less than cars (Suatmadi, Creutzig, and Otto 2019; Chiou *et al*., 2009).

Energy efficiency and carrying capacity of motorized transport vehicles are better than pick-up cars or private motorbikes for crane modifications.

The pollutant emissions generated from the hauling motorbikes are less than the hauling cars or trucks used to carry the oil palm harvest (Cepeda *et al*., 2017; Dey and Mehta 2020; Suatmadi, Creutzig, and Otto 2019). Airborne particulate pollutants such as PM10 and PM25 are emitted as emissions from motorized transport less than cars (Narita *et al*., 2019; Chan *et al*., 1995). From an environmental point of view, motorized transport is more environmentally friendly or ecofriendly to be implemented as agricultural transport vehicles.

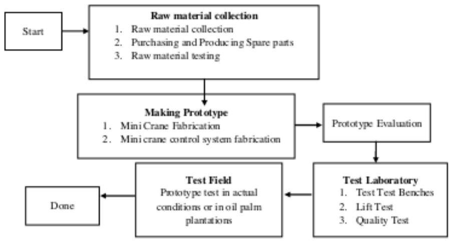
So that the right transportation for the development of mobile cranes refers to hauling motorbikes or tuk tuks.

Therefore, we developed a lifting equipment that is able to move quickly (Mobile), makes it easier to load/load palm oil from the collection point onto the truck and is ergonomic for the workforce lifting palm oil. A model of Mobile Mini Crane is built in a simple manner with a hydraulic system-based drive motor in transporting fresh fruit bunches quickly and efficiently. The development of the Mini Crane model can maintain post-harvest quality of oil palm by supporting sustainable transportation management that is eco-friendly and energy efficient.

The specific objective of this research is to create a means of transport that is able to move quickly (mobile), makes it easier to load or load FFB from TPH onto trucks and is ergonomic for laborers lifting palm fruit.

Materials and methods

Research flow chart



Mobile Mini Crane design flowchart

Research methods

Material Collection and Testing

The materials collected for the manufacture of crane frames required iron and plates. Manufacture of hydraulic machines for propelling Mini Cranes is assembled with the main components namely cylinder hydraulic cylinders, pressure pistons, joystick-based handles, and latch hooks. Apart from that, a motorized wheel, namely Motor Viar Karya 300, is needed for mobile transportation, and plastic nets with ropes for transporting fresh fruit bunches. Then material testing on plastic nets and ropes was carried out by means of a tensile test for the flexibility and resistance of the nets. The steel and plate material components are tested for material hardness for the durability of the frame and supporting legs during transportation.

Prototyping

Mini Crane fabrication is carried out by forming a frame and supporting legs. The hydraulic engine components, namely cylinder hydraulic cylinders, and pressure pistons are installed in the Mini Crane frame as the crane's driving machine. Hooks and nets are attached to the end frame of the Mobile Mini Crane. The Mini Crane control machine is semi-automatic and uses a joystick as a control device. The Mini Crane is installed on the motorized tricycle Cargo Carriage as a motor and transports the mini crane to the field.

Mobile Mini Crane Testing

The Mobile Mini Crane was tested in the laboratory with various series of test stages and direct field tests. The laboratory test consisted of a test bench test, a net carrying capacity test with a load, and a prototype quality test in the field. The test bench test that observes the durability and capability of the mini crane machine consists of 4 component stages, namely the Welding test, Hydraulic Flow test, Hydraulic strength test and deformation test. Then field testing as the last stage is carried out to test the prototype in actual field conditions or oil palm plantation land in observing the feasibility of the driving motor and all mini crane components.

Results and discussion

Discussion

The design of the Mini Mobile Crane is to combine two modified tools/machines as a means of transporting FFB from the TPH to the truck to assist the oil palm fruit harvesters in lifting the FFB onto the truck so as to minimize work accidents. The components of the tools and machines used in the design are the Viar Motor Karya 300 as a harvest transportation vehicle, a mini crane hydraulic system as a means of moving and pulling hooks, and nets as containers for lifting fresh fruit bunches. These components are assembled into a Mobile Mini Crane. installed to the Motorized Tricycle Cargo Carriage. Mobile Mini Crane Design.

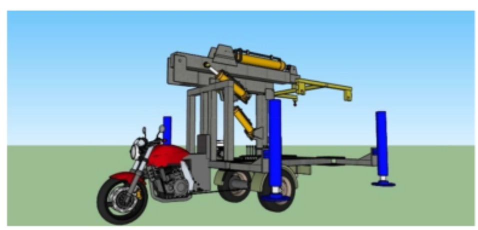


Fig. 1. Mini Mobie Crane Design.

Table 1. Dimension size of Mobile Mini Crane.

Length Size(mm)	Width Size(mm)	Size Height(mm)
3,940	1,200	1950

Choosing a motorbike as a means of transportation from an economic perspective is cheaper than using a car or truck. Motorcycles are transportation that is widely used in Indonesia and are very suitable for terrain on various access roads. Motorbikes are the right choice for the location of large oil palm plantations with relatively narrow distances between the oil palm plantations. The selection of three-wheeled motorbikes has strong power and modifications to the cargo section can be installed with a simple crane machine. The vehicle operates with a modern diesel engine which has great power and is economical in fuel consumption (Hoang 2020). Modern diesel engines are more environmentally friendly than previous generations of diesel, and their gas emissions are comparable to petrol-engined vehicles (Barrios *et al.*, 2012; Cao and others 2019). The research design of Awaludin *et al.* on Three-Wheeler Evacuation (Awaludin *et al.*, 2015) and Mobile Bunch Catcher (MBC) (Awaludin *et al.*, 2016) is the inspiration in our research in building a mobile mini crane. One of the designed mobile mini cranes uses a three-wheeled motor with diesel power based on three-wheeler evacuation and net baskets to transport and capture FFB based on MBC.

a. Stand Hydraulic and Cylinder Hydraulic Crane

Based on test bench testing on the manufacture of frames and crane hydraulic systems, hydraulic stands and hydraulic cylinder cranes can lift objects with a maximum weight of 4000kg. The Hydrolic Stand functions as a support to maintain stability when the tool operates with a capacity of 4 tons in one Hydraulic Cylinder, using flexible mounting feet so that it adapts to soil conditions in oil palm plantations. The following is a drawing of a Hydraulic Cylinder Stand.

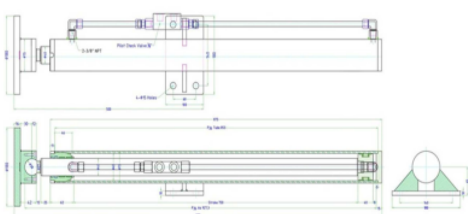


Fig. 2. hydraulic stand system design.

This Hydraulic Cylinder Crane is located on the crane mast frame which functions to lift the crane upwards when the crane is operating. Cylinder Hydraulic Crane at the bottom has a capacity of 6 tons with a stroke length of 1 meter.

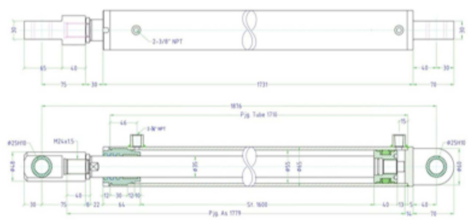


Fig. 3. Cylinder Hydraulic Crane Design.

- *Tool moment calculation*

Calculation Formula

$$W \times L_2 = F \times L_1$$

$$F = \frac{w \times l_2}{l_1}$$

Information

W (weight) = load

L_1 (weight arm) = load arm

F (force) = style

L_2 (effort arm) = power arm

Results

$$F = \frac{w \times l_2}{l_1}$$

$$F = \frac{400\text{Kg} \times 400\text{cm}}{80\text{cm}} = 2.000\text{kg}$$

Hydraulic Pump

Hydraulic pump as a tool to pump or push hydraulic oil which then fills the hydraulic cylinder.

Drive Motor

The hydraulic drive motor is a 14 HP diesel engine. The actuation of the crane lever is operated by a joystick using a dual axis controller equipped with a trigger button. The crane drive controller system is installed in the VIAR 300 three-wheeled motorcycle cargo so that the operating worker must turn around or get off first to run the crane.

Diesel Engine Specifications:

1.	type	: MDX-192 FE
2.	ModelMachine	: OHV+4not
3.	Diameter x Step (mm)	: 92 x 75
4.	Cylinder Capacity (cc)	: 498
5.	Maximum Power (Hp)	: 14

6.	Average Speed (rpm)	: 3000/36000
7.	Fuel Capacity (L)	: 5.5
8.	Engine Oil Capacity	: 1.65
9.	Ignition System	: Starter Electric
10.	Net Weight (Kg)	: 55
11.	Dimension (mm)	: 500 x 460 x 555

Automatic Lock

The Automatic Lock functions as a tool to remove the net automatically at the end of the Mini Crane. The Automatic Lock System is driven using an electrical system found on a three-wheeled motor.

Fig. 4. Automatic lock system.

Three Layers of Palm Fruit Netting

The net is made with a length and width of 2 x 2m with a 3 layer net structure. The results of measurements in the field average weight of FFB 25kg, with an average diameter of 55cm and the smallest diameter of 42cm, while the average loose fruit width is 2.3cm, and an average length of 3.6cm.

Fig. 5. Layer 3 net (bottom).

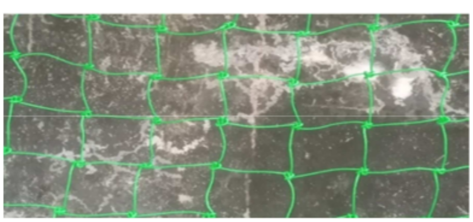


Fig. 6. Layer 2 net (middle).

Fig. 7. Net layer 1 (Top).

Based on the results of these measurements, the smallest net was made to hold loose brodolans so that they did not escape. The size of the net was 2.5 x 2.5cm and the largest net was 40 x 40cm, so that the palm fruit shavings did not escape.

Through experiments the nets made were able to lift an average FFB load of 15 FFB or 315kg. The design prototype still needs to be studied further, especially in optimizing the crane controller system so that it moves more responsively.

Research result

From the research and observations that have been made, several calculation results are obtained as follows:

Comparison Results of Lifting FFB MMC and Manual methods

Table 2. FFB Lifting Results MMC Method.

Average FFB Batch/Day (Fruit)	Average FFB Weight (Kg)	Average time (Seconds)
132	3607.7	27,6

Table 3. Yield of FFB Lift by Manual Method.

Average FFB Batch/Day (Fruit)	Average FFB Weight (Kg)	Average time (Seconds)
221	3320	33,1

ANOVA data results

Anova data is processed using SPSS 25, and from data processing the following results are obtained:

Table 4. Statistical test results with SPSS 25.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Time	Between Groups	160436976.216	1	160436976.216	14,723	.000
	Within Groups	1242232872569	114	10896779.584		
	Total	1402669848.784	115			
Number of FFB	Between Groups	.138	1	.138	.004	.947
	Within Groups	3582828	114	31,428		
	Total	3582966	115			

From the results of statistical tests using SPSS 25, the results obtained from the analysis of the amount of FFB lifted were not different but the transportation time was different, the average manual FFB transport was 6164 (1.7 minutes) per TPH while with MMC it was 4988 (1.3 minutes) and the average manual lifting weight is 172kg and 234kg using the MMC.

a. Economic Analysis

Economic analysis is made based on the value of making tools to the depreciation value of tools, and from economic analysis the results are as follows:

Tool manufacturing costs

Table 5. Tool Manufacturing Costs

Price of Three-Wheeled Motorcycles	Rp. 47.150.000,-
Other component costs	Rp. 40,000,000,-
Assembly Fee	Rp. 10,000,000,-
Total cost	Rp. 97.150.000,-

Equipment Depreciation Cost

The depreciation value is formulated by

$$\text{Depreciation Value} = \text{Tool Price} : \text{Economic age x 2} =$$

- Depreciation Value per year

$$\text{Depreciation Value} = \text{Rp. }97.150.000 : 10 \text{ Year x 2}$$
$$= 19.430.00 \text{ / Year}$$

- Depreciation value per day

Rp. 19,430,000, - / 365 Days = Rp. 53,232 / Day

- Depreciation Value perkg

Rp. 53,232 / 4,525 = Rp. 12.75,-/Kg

From the results of the economic analysis of the tool, the depreciation value of the tool is Rp. 12.75,-/Kg

Net Depreciation Value

Net Price	Rp. 230.000,-

Information :

Lifespan of the net : 250 Days

Average FFB batch : 234 Forces /day

$$\text{Depreciation Value} = \text{Rp. }230.000 : 250 : 234$$
$$= \text{Rp. }3{,}39/\text{ transport}$$

Variable Cost

Diesel fuel	Rp. 27,200, - / day
BBM	Rp. 20,000,- / day
Care	Rp. 1923.08, - / day
Operator	Rp. 50.000,- / day
Total cost	Rp. 99,123.08- / hour

Rp. 99,123.08 / 135 hours = 734.25

Rp. 734.25: 234 = 3.24 /kg

MMC operational costs

Rp. 12.75 + 3.39 +3.24 /kg = Rp. 19.82,-/kg

Literature Review

The evacuation of oil palm Fresh Fruit Bunches (FFB) is currently starting to lead to mechanization of harvesting activities. Reasons for time efficiency and labor costs for harvesting harvests in the field have encouraged the development of crane grabber machines and special transportation for the palm oil industry. So that a lot of research has been developed related to mechanization of grabber machines and transportation for the palm oil industry in Southeast Asia (Choy and Hoak 2000; Harsawardana *et al.*, 2020; Aljawadi *et al.*, 2021). The development of the Mini Tractor as transportation in a Compact Transporter was developed by Deraman and the team's research(Mohd Solah Deraman *et al.* 2006)to transport FFB in the field. A single chassis engine with four low-pressure tires, and a steering motor make it easy to move the Compact Transporter. Flexible maneuvers make it easier for the Compact Transporter to navigate narrow and bumpy terrain conditions. A Mini Tractor with Multipurpose Wheel Type Transporter named Rhyno was designed and used as a continuation of the development of the Compact Transporter (MS Deraman *et al.*, 2013). The containers at Rhyno are equipped with a hydraulic drive machine to move the harvested FFB to a storage area (bin). The Three Wheeler Evacuation utilizes a cargo motorbike with a diesel engine as the main vehicle in this transportation design (Awaludin *et al.*, 2015). These customized vehicles have a lot of power and are able to navigate narrow terrain compared to other transportation modifications for FFB evacuation. The need for fuel and the amount of labor absorption is more efficient than the modification of a diesel-powered Mini Truck on oil palm plantations.

Mechanization with a hydraulic system to catch or take FFB directly from each palm tree is made in the form of a net basket and grabber. The hydraulic system is installed on vehicles transporting crops to speed up the evacuation of FFB in oil palm plantations (Sarip *et al.*, 2020). Transport vehicles in the form of Mini Trucks are the most widely used in designing Mobile Mini Cranes for harvesting harvests (Aljawadi *et al.*, 2021; Choy and Hoak 2000). The Mobile Crane Grabber design has been applied in oil palm plantations in previous studies, including the Grabber (Black and Ibrahim 1992), Mark 2 Grabber (Ahmad and Abd Rahim 1995), Wakfoot MK2 with Grabber (Ahmad and Abd Rahim 2000). The Mini Tractor is also installed with a Grabber engine with greater power and payload capacity. In Shuib *et al.* research. (Abd Rahim *et al.*, 2020), the 4WD and 6WD tractor engine drive systems are used to design the Mobile Mini Crane for TBS Grabber. Apart from grabbers, net baskets are used to catch palm fruit, especially those that will be released to the ground during harvesting. Awaluddin *et al.* (Awaludin *et al.*, 2016) developed a Mobile Bunch Catcher to catch loose FFB to help evacuate crops. The basis of transportation in the design is a diesel-powered Mini Truck with small dimensions.

Conclusion

The Mobile Crane design has been carried out to lift fresh fruit bunches of oil palm from the place where the results are stored onto the truck bed. The Mobile Mini Crane is a Postharvest Technology that is capable of helping harvesters to lift FFB onto the truck, thereby reducing the risk of work accidents and avoiding damage to the body. Especially the bones. Various pre-design trials and data analysis have been completed. Currently, the Mobile Crane prototype can transport a load of 20 units of fresh fruit bunches or the equivalent of 400kg. These results will be used as the basis for completion of construction. Prototype construction is still under development and optimization in the field to increase yield mobilization. The Mini Crane hydraulic system, which is still manual and semi-automatic, is still being developed towards full automation with the implementation of Artificial Intelligence (AI). From an ergonomic perspective, it can reduce the risk of fatigue to harvesters. Work performance of Mobile Mini Crane is more effective and efficient than manual labor. In terms of economic calculations, Mobile Mini Crane is much more efficient than manual labor with a price difference of Rp. 19.82/Kg.

References

Abd Rahim, Shuib, Mohd Khairul Fadzly Md Radzi, Mohd Azwan Mohd Bakri, Mohd Ramdhan Mohd Khalid. 2020. Development of a Harvesting and Transportation Machine for Oil Palm Plantations. Journal of the Saudi Society of Agricultural Sciences **19(5)**, 365-73.

Ahmad, HJ, and Shuib Abd Rahim. 1995. The Grabber Mark 2 An Automatic Mechanical Loader. MPOB Information Series TT **18**, 1-2.

Aljawadi, Rafea AM, Desa Ahmad, Nazmi M Nawi, Muhamad SM Kassim, Wan IW Ismail. 2021. A Review of the In-Field Transporting Machines Currently Used in Oil Palm Plantations in Malaysia. Basrah Journal of Agricultural Sciences **34**, 119-37.

Awaludin, Azali, Syed Syed Salim, Abdul Halim Zainal Abidin, Mohd Rosdi Ngah. 2015. Performance Study of an Oil Palm Fresh Fruit Bunch Three Wheeler Evacuation Machine. The Online Journal of Science and Technology **5(2)**, 46-53. https://doi.org/https://doi.org/10.1016/j.rser.2010.07.062

Awaludin Azali, Syed SSA, Abdul Halim ZA, Rasidi I. 2016. Performance Study of an Oil Palm Mobile Bunch Catcher. International Journal of Engineering Innovation & Research **5(6)**, 384-88.

Barrios CC, A Dom inguez-Sáez, Rubio JR, Pujadas M. 2012. Factors Influencing the Number Distribution and Size of the Particles Emitted from a Modern Diesel Vehicle in Real Urban Traffic. Atmospheric Environment **56,** 16-25.

Cao, Duc Thiep, others. 2019. A Brief Review of Technology Solutions on Fuel Injection Systems of Diesel Engines to Increase the Power and Reduce Environmental Pollution. Journal of Mechanical Engineering Research & Developments (JMERD) **42(1),** 1-9.

Cepeda, Magda, Josje Schoufour, Rosanne Freak-Poli, Chantal M Koolhaas, Klodian Dhana, Wichor M Bramer, Oscar H Franco. 2017. Levels of Ambient Air Pollution According to Mode of Transport: A Systematic Review. The Lancet Public Health **2(1),** e23-e34.

Chan, Chang-Chuan, Chiu-Kuei Nien, Cheng-Yuan Tsai, Guor-Rong Her. 1995. Comparison of Tail-Pipe Emissions from Motorcycles and Passenger Cars. Journal of the Air & Waste Management Association **45 (2),** 116-24.

Chiou, Yu-Chiun, Chieh-Hua Wen, Shih-Hsun Tsai, Wei-Ying Wang. 2009. Integrated Modeling of Car/Motorcycle Ownership, Type and Usage for Estimating Energy Consumption and Emissions. Transportation Research Part A: Policy and Practice **43(7),** 665-84.

Choy, Chow Kok, Ooi Ling Hoak. 2000. An Improved Field Practice and Mechanization of FFB Evacuation and Manuring in Oil Palm Plantations. In 2000 PIPOC Proceedings: Emerging Technologies and Opportunities in the Next Millennium, 454-76. Kuala Lumpur.

Chrisendo, Daniel, Hermanto Siregar, Matin Qaim. 2021. Oil Palm and Structural Transformation of Agriculture in Indonesia. Agricultural Economics **52(5),** 849-62.

Chwastek, Stefan. 2020. Optimization of Crane Mechanisms to Reduce Vibration. Automation in Construction **119,** 103335.

Deraman MS, AbdRahim S, Zaprunnizam MA, Aminulrashid M, Hartini MDH. 2013. Rhyno: A Multipurpose Wheel Type Transporter for Oil Palm Activities on Undulating Terrain and Soggy Areas. MPOB Information Series TT **535,** 29-32.

Deraman, Mohd Solah, Ahmad Hitam, Aminulrashid Mohamed, others. 2006. Compact Transporter for In-Field Activities. MPOB Information Series TT **316,** 2-3.

Dey S, Mehta NS. 2020. Automobile Pollution Control Using Catalysis. Resources, Environment and Sustainability **2,** 100006.

Harsawardana, Reza Rahutomo, Bharuno Mahesworo, Tjeng Wawan Cenggoro, Arif Budiarto, Teddy Suparyanto, Don Bosco Surya Atmaja, Bayu Samoedro, Bens Pardamean. 2020. AI-Based Ripeness Grading for Oil Palm Fresh Fruit Bunch in Smart Crane Grabber. IOP Conference Series: Earth and Environmental Science **426,** 12147.

Black, Ahmad, Ahmad Ibrahim. 1992. The Grabber-An Important Development towards Reducing Dependence on Labor. MPOB Information Series TT 3.

Hoang, Anh Tuan. 2020. Applicability of Fuel Injection Techniques for Modern Diesel Engines. In AIP Conference Proceedings **2207,** 20018.

Ishak, Andi, Rilus A Kinseng, Satyawan Sunito, Didin S Damanhuri. 2017. Palm Oil Expansion and Requirement Spatial Planning Policy Improvement. Perspectives **16(1),** 14-23.

Kalwasiński, Dariusz. 2018. Mobile Simulator of the Crane to Support Trainings of Crane Operators--a Concept. Mechanic **91 (7),** 609-11.

Lim, Chun Hsion, Zi Hooi Cheah, Xi Him Lee, Bing Shen How, Wendy Pei Qin Ng, Sue Lin Ngan, Steven Lim, Hon Loong Lam. 2021. Harvesting and Evacuation Route Optimization Model for Fresh Fruit Bunch in the Oil Palm Plantation Site. Journal of Cleaner Production **307,** 127238.

Muhammad, Luthfi Norzan, AB Shahriman, BMT Shamsul, Baba M Deros, Azmin Sham Rambely, YG Ng, Mohamad Razlan Zuradzman. 2015. Conceptual Design for Oil Palm Evacuation to Improve Ergonomics Issues of Collecting Fresh Fruit Bunch. In Applied Mechanics and Materials **786,** 281-86.

Narita, Daiju, Nguyen Thi Kim Oanh, Keiichi Sato, Mingqun Huo, Didin Agustian Permadi, Nguyen Nhat Ha Chi, Tanatat Ratanajaratroj, Ittipol Pawarmart. 2019. Pollution Characteristics and Policy Actions on Fine Particulate Matter in a Growing Asian Economy: The Case of Bangkok Metropolitan Region. Atmosphere **10(5),** 227.

Pfaffenbichler, Paul, and Giovanni Circella. 2009. The Role of Motorized 2-Wheelers in an Energy Efficient Transport System. Proc. of the European Council for an Energy Efficient Economy, Le Colle Sur Loup, Côte d'Azur 1345-54.

Sarip S, MA Suhot, HM Kaidi, MF Mohd Noor, S Abdul Aziz, NA Bani, MS Noorazizi. 2020. Hydraulically Operated Palm Oil Loader System Design as Fresh Fruit Bunch Collector. Indonesian Journal of Electrical Engineering and Computer Science **17(1),** 228-36.

Suatmadi, Anissa Yuniashaesa, Felix Creutzig, Ilona M Otto. 2019. On-Demand Motorcycle Taxis Improve Mobility, Not Sustainability. Case Studies on Transport Policy **7(2),** 218-29.

Sun Guangfu, Michael Kleeberger. 2003. Dynamic Responses of Hydraulic Mobile Crane with Consideration of the Drive System. Mechanism and Machine Theory **38(12),** 1489-1508.

Wu Di, Jing Zhang, Shun De Gao, Xin Wang. 2010. Modeling Method of Crawler Crane Based on Open Source Engines. In Advanced Materials Research **97,** 2832-35.

Design of a mobile mini crane for loading to truck to reduce damage to fresh fruit loans (FFB) during transport

ORIGINALITY REPORT

16%	14%	9%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	psasir.upm.edu.my Internet Source	3%
2	Submitted to Institut Pertanian Bogor Student Paper	2%
3	bjas.bajas.edu.iq Internet Source	2%
4	Submitted to UC, San Diego Student Paper	1%
5	ukmsarjana.ukm.my Internet Source	1%
6	www.mitpressjournals.org Internet Source	1%
7	Binzhe Wang, Siqi Zheng. "Air pollution lowers travel demand in a consumer city", Transportation Research Part D: Transport and Environment, 2020 Publication	1%
8	onlinelibrary.wiley.com Internet Source	

		1%
9	Submitted to Shawnee Mission Public Schools Student Paper	1%
10	Submitted to TechKnowledge Student Paper	1%
11	www.tandfonline.com Internet Source	1%
12	Ioanna Spyropoulou, Eriola Impersimi. "Powered-two-wheelers and smart cities: the case of variable message signs", IET Intelligent Transport Systems, 2021 Publication	1%
13	Submitted to Universiti Teknologi MARA Student Paper	1%
14	businessdocbox.com Internet Source	1%
15	Mohd Zulfahmi Mohd Yusoff, A. Zamri, M. Z. A. Abd Kadir, W. Z. Wan Hassan, N. Azis. "Development of integrated loose fruit collector machine for oil palm plantations", Bulletin of Electrical Engineering and Informatics, 2019 Publication	1%
16	innspub.net Internet Source	1%

17	openknowledge.worldbank.org Internet Source		1%

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	Off		