The Design Prime Mover for Mechanical Hand Installer Pull Clamp Isolator

I Gede Nyoman Suta Waisnawa[a], I Wayan Jondra[b], I Gede Suputra Widharma[c],
I Komang Kantun, I Putu Agus Haryawan and I Dewa Made Haruna Putra
Mechanical Engineering Department, Politeknik Negeri Bali, Jalan Kampus Bukit Jimbaran, Kabupaten Badung, Indonesia

Keywords: Electric Motor, Mechanical Hand, Isolator, Efective, Times.

Abstract: PLN has not been able to meet the SAIDI (System Avarage Interupption Duration Index) and SAIFI (System Avarage Interupption Frequency Index) standards. One of the causes of the non-fulfillment of SAIDI and SAIFI standards in Indonesia is external disturbances, namely disturbances caused by nature or outside the system, for example trees that are towering up to touch the connection point so as to cause a short circuit. The presence of tekep insulators gives hope to PLN to overcome natural external disturbances caused by trees, animals and so on.The previous installation of the insulator is done by cutting off the electricity in the network cable. The power outage during the installation of the insulator is certainly detrimental to the customer. This condition gave rise to the idea of making mechanical aids for the installation of insulators to make installation easier without breaking the electricity supply to the network cable. The components purchased include an electric motor as a driving force, a screw transmission. While the components made are pressure plates, drive arms, hinges, motor mounts, clutches, and locking axles.The results of tests carried out by installing an insulator using a mechanical hand on the cable connection on the power pole. The installation of the insulator plug by mechanical hand was tested on 3 connections and carried out 5 times on 1 connection on the power pole. The test results of installing an insulator on 1 connection using a mechanical hand obtained an average time of 8 minutes 40 seconds.

1 INTRODUCTION

Economic activities that are: office activities, shops, factories/industries (small and large scale), malls, households, all of them need electricity. The growth in electrical energy as happened in China is dominated by consumer growth in the housing sector (Zhaoguang, Xiandong, & Zhaoyuan, 2014). Indonesia is also growing in the use of electrical energy which is quite high. Electricity is the foundation sector for achieving development goals, such as creating job opportunities, increasing national income, changing the economic structure and improving people's welfare (Santika Wayan G, Urme, Eliz, A.Bahri, & Anisuzzaman, 2020). The distribution reliability system has a vital need to keep electricity on for 24 hours a day. Thus, the value of SAIDI and SAIFI must be minimized as small as possible.

The distribution reliability index is calculated by value of SAIDI (System Average Interupption Duration Index) and SAIFI (System Average Interupption Frequency Index) as reliability indicators. In most areas in Indonesia PLN has not been able to meet SAIDI and SAIFI standards (Math, 2013). To minimize planned power outages or disturbances, mechanical hands are needed to install distribution line accessories such as Strain Clamp Cover on Live Line Condition.

For this mechanical hand driver, a driving mechanic is needed. Thus, this study discusses the driving mechanics needed for this mechanical hand

[a] https://orcid.org/0000-0001-7163-6813
[b] https://orcid.org/0000-0001-6800-6415
[c] https://orcid.org/0000-0002-7090-545x

Waisnawa, I., Jondra, I., Widharma, I., Kantun, I., Haryawan, I. and Putra, I.
The Design Prime Mover for Mechanical Hand Installer Pull Clamp Isolator.
DOI: 10.5220/0011756700003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 252-257
ISBN: 978-989-758-619-4; ISSN: 2975-8246
Copyright © 2023 by SCITEPRESS – Science and Technology Publications, Lda. Under CC license (CC BY-NC-ND 4.0)

driver. It takes a mechanical drive with a low speed but has a high torque. The use of a speed gearbox reducer with a speed ratio of 20:1 will result in an increase in force of 1:20 (Sarma, 2017). For the robot hand driver, a DC electric motor will also be used which is equipped with a gearbox (Peerzada, Larika, & Mahar, 2021). The problem is how much motor power is needed and how much dimention or diameter of shaft drive.

2 RESEARCH METHODE

2.1 Research Approach and Concept

Descriptive qualitative research was carried out with an approach study to plan the mechanism of mechanical hand movements. The compressive force required to move this mechanical hand so that it is able to close and open properly. The estimation of the determination of the compressive force is carried out by simulating loading by pouring water into a vessel that is supported directly above the mechanical hand until it is able to close the insulator clamp clamp properly..

The concept of this research is to convert the required mechanical compressive force at the end of the pressure point into the required electric motor power. Based on the power of the electric motor needed, research on the needs of the motor driver and drived shaft is needed.

The test of compressive force required the based load point is carried out by giving the load at the based load point gradually. The weight of the load at the based load point in the time of the mechanical hand closes the cover strain clamp completely, the weight of the load is recorded and multiplied by the acceleration / gravity of the earth as the required compressive force.

2.2 Sample

This study uses a mechanical hand prototype as a sample in testing the pressure force on a mechanical hand, determining motor power. In this research using 3 sample mechanical hand prototype. Mechanical hand function test to determine the time required to install an insulator cap on a 20 kV medium voltage distribution network cable. Time measurement was carried out 15 times for each line, namely line R, line S and line T. Water loading are 10 times for each sample.

2.3 Variable Operational Definition

The focus of this study to observing the magnitude of the indicators of this research, that are : force, power, and battery capacity. Voltage is amount in volt of potential test voltage between two terminal of motor DC. The current is amount in amper of electron flow from battery to the motor DC. Power in watt or newton yang calculated to real load on the base point of load. Battery capacity was calculated to the battery insertion in to the mechanical hands (Xiaopeng., Weixiang, Tu, Zhenwei, & Kapoor, 2012).

2.4 Data Analysis

Data obtained from the test results and nameplate are processed quantitatively. Data processed mathematically and statistically by finding the data variation on the step on each water filling. The data are processed mathematically to obtain the power of electric motor needed for prime mover, nominal drive shaft diameter, rotation drive shaft, current and power supplay. The output mathematically data is processed trough statistically to obtain the average data, data sequence, which is also displayed graphically.

3 RESULT AND DISCUSSION

3.1 Force, Torque, DC Motor Power, and Drive Shaft

3.1.1 Force

Newton's second law of motion points out the magnitude of force when velocity of body move in force is proportional to impressed force. Mathematically, can be describe Force was change in velocity. That issue is now second law of motion is based on definition of equation of force is weigh multiple with velocity for horizontal move, and with earth gravitation for vertical move, that are as describe on this formula in below (Sarma, 2017)

$$F = m.a \quad (1)$$

The formula above can be explained that the value of the force (F) is determined by the mass value (m) of the object multiplied by the acceleration (a). The unit of force is measured in Newtons, the unit of mass of an object is measured in kg and the unit of acceleration is measured in m/s^2 (Caldwell, Robertson, & Whittlesey, 2020)(Ariadi & Dinata, 2018).

The required of compressive force of the robotic hand to close the strain clamp cover is carried out by tested using a dummy load by a water container. The water container is placed at the end point of load from the fulcrum. Water is poured into the container slowly until the robotic hand closes to closes the strain clamp cover. When the strain clamp cover is completely closed, the water pouring is stopped.

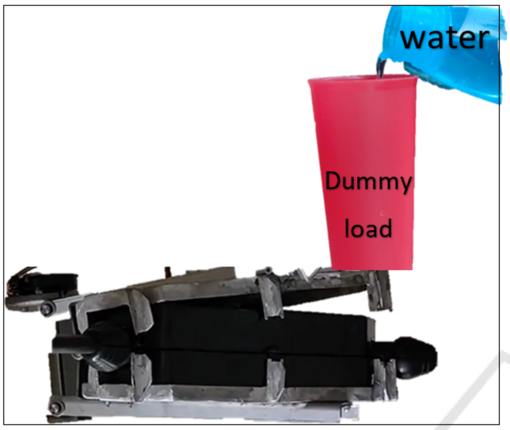


Figure 1: Loading test.

The loading test by pouring water into the vessel as shown in Figure 1 obtained the weight of water (dummy load) until it was able to press the mechanical hand to close the insulator cover clamp properly was 0.84 kg. The weight of this water is then multiplied by the acceleration of gravity as shown in table 1

Table 1: Force test result.

No	Sample 1		Sample 2		Sample 1	
	Weight (Kg)	Force (N)	Weight (Kg)	Force (N)	Weight (Kg)	Force (N)
1	0.9	8.82	0.85	8.33	0.84	8.23
2	0.89	8.72	0.84	8.23	0.88	8.62
3	0.85	8.33	0.84	8.23	0.87	8.53
4	0.82	8.04	0.83	8.13	0.85	8.33
5	0.8	7.84	0.85	8.33	0.82	8.04
6	0.85	8.33	0.84	8.23	0.8	7.84
7	0.84	8.23	0.83	8.13	0.83	8.13
8	0.83	8.13	0.83	8.13	0.84	8.23
9	0.83	8.13	0.82	8.04	0.83	8.13
10	0.82	8.04	0.85	8.33	0.83	8.13
Average Weight (Kg)			0.84	Average Force (Newton)		8.23

3.1.2 Pressing Moment

The compressive moment is determined based on the compressive force that has been obtained using the moment equilibrium principle as shown in Figure 2

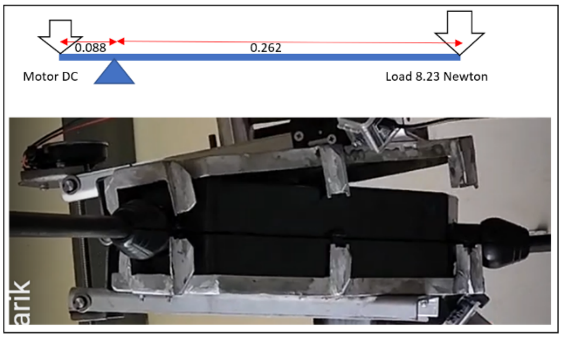


Figure 2: Hand Mechanic Load Distribution.

The compressive force obtained from the test results of 8.23 N is F2, F1 is the force that is in the position of the driving motor. F1 is calculated using the moment equilibrium concept as follows:

$$MP = F1 \frac{0.342\ m}{2}$$

$$MP = 24.51\ N.\, 0.171\ m$$

$$MP = 4.1895\ Nm$$

Tightening Moment is assumed as Torque (T) in determining power drive motor.

3.1.3 DC Motor for Prime Mover

Direct Current Motor Trough electromagnetic converts the direct current electrical energy to mechanic energy (Qader, 2017). Electricity in a DC motor is flowed into the field coil so as to produce magnetic flux, electricity is also flowed through the charcoal brush to the rotor coil, so that the rotor coil produces a rotor field. The size of the mechanical power produced by the electric motor is greatly influenced by the size of the field coil and the rotor coil, so that the larger the coil, the greater the current that flows and so that the electrical power consumed is greater, resulting in large mechanical power (Iswanto, Ma'arif, Puriyanto, Raharja, & Rahmadhia, 2020; Ranjbar, Anahita Banei, & Fahimi, 2012).

To reverse the rotation of the rotor can be done by reversing the incoming current to the DC motor terminal, which was originally positive connected to a negative voltage source, and vice versa the negative one was connected to a positive voltage source (Purnata, Ramadan, Hidayat, & Maulana, 2022). This reversal of the motor terminals will result in the reverse direction of the current entering the motor, so that the motor rotation is reversed. This phenomenon occurs in accordance with the law of the left hand which reads: the index finger indicates the direction of the current, the thumb indicates the direction of the pulsation, and the other three fingers indicate the direction of the field.

The motor power (P) required to move the mechanical hand so that it is able to press the insulator cover clamp properly is as follows

$$P = \frac{2\pi n T}{60}$$

$$P = \frac{2 \text{ x } 3.14 \text{ x } 86.2 \text{ x } 4.1985}{60}$$

$$P = 37.798 \text{ watt}$$

Nominal power obtained P = 37,798 watts

The design power (Pd) is multiplied by the correction factor (fc), for the average power the correction factor is chosen 1.2 (Sularso & Suga, 2004). Power Design (Pd) can be obtain is 45,3585 watt

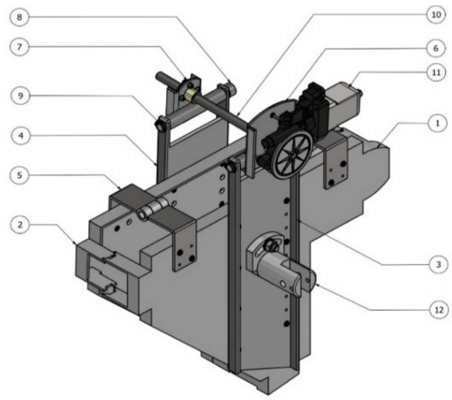
Based on the calculations above, for the mechanical hand driver, a motor above 24.5 watts is needed. Found on the market a complete DC motor gearbox, with a capacity of 48 watts, 12 volts, 4 amperes as shown in the picture below.

Figure 3: DC Motor 48 watts.

To drive the mechanical hand, the gearbox motor is coupled with a trapezoidal thread to propel the robotic arm. Tested is Installed the performance of the motor in the mechanical hand, to determine its electrical power consumption.

3.2 Mechanical Hand Prototype Design

Mechanical hand prototype design with electric motor as prime mover. This mechanical hand is used to attach the pull clamp isolator cap.



1. Fixed clamping press plate
2. Movable clamping press plate
3. Fixed hand
4. Hands move
5. Hinge
6. Electric motor mount
7. Threaded transmission nut holder
8. Locking pen
9. Rings and snap rings
10. Threaded transmission
11. Electric motor
12. Clutch

Figure 4: Prototype Design of Mechanical Hand.

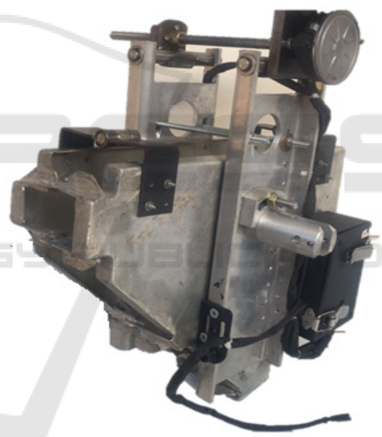


Figure 5: Prototype of Mechanical Hand.

3.3 Power, Rotation and Torque Test Results

Direct Current Electric Motor Performance Testing.The DC motor is coupled with a trapezoidal thread shaft for opening and closing of the mechanical hand. The DC motor that has been determined is then tested for mechanical hand closing movement. When installing the insulator cover, the data taken are Power, Rotation of the drive shaft and the time of installing the insulator cover.

Table 2 show that the measurement and calculation data that show the relationship between power, rotation and torque. The lowest rotation is 25.94 rpm with a torque of 11.83 Nm

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

Table 2: Power, Rotation and Torque Test Result.

Average		Power (Watts)	Rotation (Rpm)	Torque (Nm)
Voltage (Volt)	Current (Amp)			
5,30	1,36	16,28	40,53	3,84
9,63	1,34	16,12	50,65	3,04
9,77	1,70	20,40	60,54	3,22
9,63	1,48	17,80	84,00	2,02
9,83	1,67	20,08	85,84	2,23
9,60	1,90	22,80	84,73	2,57
9,77	1,67	20,08	84,62	2,27
9,53	1,68	20,20	85,84	2,25
9,63	1,79	21,52	82,45	2,49
9,47	1,79	21,52	75,42	2,73
9,10	2,22	26,64	60,22	4,23
9,50	2,15	25,84	45,30	5,45
6,60	2,68	32,12	25,94	11,83

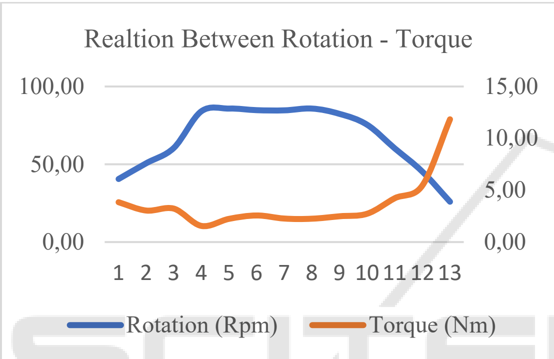


Figure 6: Relatian between Rotation – Torque.

Figure 6 show that the relationship between rotation and torque that occurs when installing the insulator cover when tightening is when the rotation goes down, it means the torque increases because the power required is the same for tightening the insulator clamps evenly.

While the duration of time in the process of installing the insulator cover by mechanical hand is shown in Table 3 below.

Table 3: Duration Time Installing Insulator Cover.

No	Duration Time (Second)		
	Line 1	Line 2	Line 3
1	39,71	39,61	46,59
2	37,73	35,7	40,57
3	36,55	37,29	40,41
4	36,76	35,51	38,23
5	36,59	37,38	40,51
6	38,71	36,61	45,58
7	37,57	36,58	40,67
8	37,14	37,29	40,41
9	36,75	35,51	38,23
10	36,79	37,36	39,55
Average	37,43	36,884	41,075

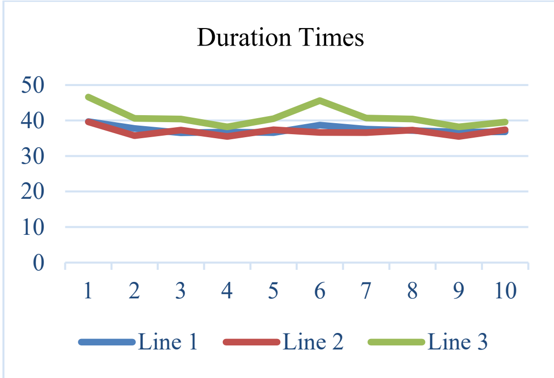


Figure 7: Duration Time Installing Insulator Cover.

The graph in Figure 7 shows that there is a time difference in the process of installing the insulator cover by mechanical hand for each line, but the time difference is small, so it can be stated that the installation time is almost the same.

4 CONCLUSIONS

Based on the results of testing and analysis can be concluded as follows:

1. The working load on the mechanical arm is 8.23 Newtons. The main driving power from the calculation results is 45.3585 watts. The DC motor selected according to availability in the market is a 12 Volt, 48 Watt DC Motor.
2. The maximum torque required to drive the mechanical hand is :5.45 Nm at 25.94 rpm.
3. The average time of installing the insulator cover is 38,463 seconds.

ACKNOWLEDGEMENTS

This research was funded by Lembaga Pengelola Dana Pendidikan dan Direktorat Jenderal Pendidikan Vokasi Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Year 2021. We thank Project Management Office of Domestic Vocational Higher Education Program Implementation of the Applied Scientific Research in 2021 for his support to this research..

REFERENCES

Ariadi, P., & Dinata, C. (2018). Students' Mental Model About Newton' S Third Law in Indonesia: Analysis and

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

Suggestion To Overcome It. *Unnes Science Education Journal (USEJ)*, *7*(2), 146–155.
Caldwell, G. E., Robertson, D. G. E., & Whittlesey, S. N. (2020). Forces and Their Measurement. In *Research Methods in Biomechanics*. https://doi.org/10.5040/9781492595809.ch-004
Iswanto, Ma'arif, A., Puriyanto, R. D., Raharja, N. M., & Rahmadhia, S. N. (2020). Arduino Embedded Control System of DC Motor Using Proportional Integral Derivative. *International Journal of Control and Automation*, *13*(4), 658–667.
Math, K. (2013). Through-life management of electric vehicles. *International Through-Life Engineering Services Conference, Procedia CIRP 11 (2013) 2nd.*, 260 – 265.
Peerzada, P., Larika, W. H., & Mahar, A. A. (2021). DC Motor Speed Control Through Arduino andL298N Motor Driver Using PID Controller. *International Journal of Electrical Engineering & Emerging Technology*, *04*(2), 21–24.
Purnata, H., Ramadan, S., Hidayat, M. A., & Maulana, I. (2022). *PID Control Schematic Design for Omni-directional Wheel Mobile Robot Cilacap State of Polytechnic*. *12*(2), 89–94.
Qader, M. R. (2017). Identifying the Optimal Controller Strategy for DC Motors. *IAES International Journal of Robotics and Automation (IJRA)*, *6*(4), 252. https://doi.org/10.11591/ijra.v6i4.pp252-268
Ranjbar, A. H., Anahita Banei, A. K., & Fahimi, B. (2012). Online estimation of state of charge in Li-Ion batteries using implse respone concept. *IEEE Transactions on Smart Grid*, *3*(1).
Santika Wayan G, Urme, T., Eliz, S., A.Bahri, P., & Anisuzzaman, M. (2020). An assessment of energy policy impacts on achieving Sustainable Development Goal 7 in Indonesia. *International Energy Initiative.*, *59*(December), 33–48. Retrieved from https://www.sciencedirect.com/science/article/pii/S0973082620302921
Sarma, A. (2017). TECHNOLOGY. *International Journal of Engineering Sciences & Research Technology*, *6*(12), 57–79.
Sularso, & Suga, K. (2004). *Dasar Perencanaan dan Pemilihan Elemen Mesin. Jakarta*. Jakarta: Pradnya Paramita.
Xiaopeng., C., Weixiang, S., Tu, V. T., Zhenwei, C., & Kapoor, A. (2012). An overview of lithium-ion batteries for electric vehicles. *Nternational Power & Energy Conference, December 2012.*
Zhaoguang, H., Xiandong, T., & Zhaoyuan, X. (2014). *A Review of china's economic development and electricity consumption, An Exploration into China's Economic Development and Electricity Demand by the Year 2050.* Cambridge: Elsevier Inc.

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS