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PROCEEDING

The 1st International Conference On Engineering Technology Innovation For Archipelago

(ICETIA-2016)

"Green Technology For A Better Future"

Faculty Of Engineering
Universitas Khairun

Greetings from Dean of Engineering Faculty

Bismillahirrahmanirrahim,

Assalamu Alaykum Warahmatullahi Wabarakatuh.

Gratitude Praise to Allah SWT, who given us a guidance and blessing.

Faculty of Engineering is one of eight faculties at Khairun University. Currently, Faculty of Engineering has entered its 15th years. Recently, Faculty of Engineering has six study programs. They are Civil Engineering, Mechanical Engineering, Electrical Engineering, Architectural Engineering, Informatics Engineering, and the last is Mining Engineering. We have 84 lecturers, 15 skilled staffs, and around 1,600 registered students.

I thank to you all honorable keynote speakers from Malaysia, Japan International Cooperation Agency (JICA), Timor Leste, and private sector. Participants to the conference mostly come from Eastern Indonesia. To all participants, we welcome you to Ternate and join this conference.

The title for this conference is "The 1st International Conference on Engineering, and Technology Innovation for Archipelago (ICETIA 2016)." The main theme is "Green Technology for a Better Future." It lasts for two days on October 27-28, 2016. The conference will be held annually.

The main purpose of this activity is to collect and disseminate recent innovation in engineering, science, and green technology to be applied in archipelago region. The conference meets university academicians and researchers, industries, and government, both local and regional in Eastern Part of Indonesia.

In line with the theme of this conference, we hope we can explore and expand all of our potencies. The conference of course enriches the capacity of stakeholders in engineering, science, and technology.

The steering committee and organizing committee gave special thanks to Khairun University Rector, Prof. Dr. Husen Alting, S.H., M.H. and all Vice Rectors who are always supporting our activities.

Last but not at least, I, on behalf of Engineering Faculty Khairun University, thanks to all of our generous sponsors succeeding this conference.

Ternate, October, 27, 2016

Selamat datang…!

Welcome…!

歓迎

Bem-vindo…!

Ir. Ahmad Seng, M.Eng.

Dean of Engineering Facu

MICRO HYDRO POWER PLANT DESIGN IN IBU VILLAGE, WEST HALMAHERA IN REALIZING AN AUTONOMOUS ENERGY VILLAGE

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Abstract- Energy is one of the main needs in human life. Energy enhancement can be an indicator of increasing prosperity of an area but simultaneously it also poses problems in supply. An adequate and cheap as well as environmentally friendly electrical energy supply for sustainable economic and social development. Limitations of electrical energy is one of the obstacles in the construction and development of rural communities.

The micro-hydro power plant is selected as one of the alternative energy that are environmentally friendly, pollution-free, renewable (renewable), not consumptive of water use, durable (long life), and small operational cost is suitable for remote areas. The potential of water energy in the province of North Maluku contained in several regions including in Ibu Village, West Halmahera. Hydropower potential has been exploited is still relatively small. The utilization of hydropower proficiency level is still relatively small because the potential is usually located in remote areas that electricity demand is relatively small so for micro hydro potential are located far from consumers has not been utilized.

This type of research is a quantitative research through a case study approach (case study). This study tried to design a micro hydro power with a capacity of 500 watts. The research location is in Ibu village, West Halmahera, North Maluku. Design and manufacture prototypes of micro hydro power is done in engineering lab and Mechanical Engineering workshop, University of Khairun. Technique of collecting data through observation and direct observation in the field and literature studies, while engineering analysis is done by making the basic design concept of micro hydro power, process design, simulation using ANSYS 14.5 software, and real experimental by making real prototypes of micro-hydro power and tested in the study site. The findings of this research is the design of the prototype micro-hydro power with a power generator 500 WA and inverter output 1000 Watt.

Keywords: design, micro hydro power, autonomous energy village

1.1. Introduction

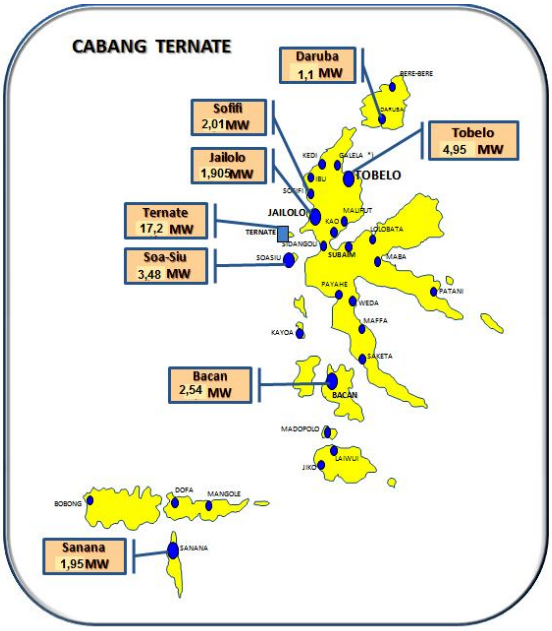
Energy is one of the main needs in human life. Energy enhancement can be an indicator of increased prosperity of an area, but simultaneously it also poses problems in supply. An adequate and cheap as well as environmentally friendly electrical energy supply for sustainable economic and social development. Limitations of electrical energy is one of the obstacles in the construction and development of rural communities.

Water is the source of energy that is cheap and relatively easy to obtain because of the potential energy stored water (water falls) and kinetic energy (in running water). Water power (hydropower) is the energy obtained from flowing water. The energy possessed by the water can be harnessed and used in the form of mechanical energy and electrical energy. The utilization of water energy is mostly done by using a water wheel or water turbine which utilizes the existence of waterfall or water flow in the river. Since the beginning of the eighteenth century water mill widely used as the driving mill, sawmill and textile machinery. Entering the nineteenth century water turbine was developed.

Water energy is the energy that is used widely in Indonesia in a large scale has been used as a power plant. Some companies in the field of agriculture even have their own power plants sourced from hydro energy. In the future, rural areas that are far from the national grid, the energy generated can be through micro hydro is expected to grow rapidly.

The micro-hydro power plant was selected as one of the alternative energy that are environmentally friendly, pollution-free, renewable (renewable), not consumptive of water use, durable (long life), and small operational cost is suitable for remote areas. MHP also has potential as a reinforcement pattern of modern forest management for the community to restore the environment and forest resources. Efforts to develop micro-hydro is a constructive effort to urge people to care about the environment. Micro hydro is made or constructed by the fact that the water flowing in an area with adequate capacity and altitude. The term capacity refers to the total volume of water flow per unit time (flow capacity) while the height difference to the flow of the installation area is known as the head. Micro hydro also known as white energy resources for power plant installations using the resources provided by nature and environmentally friendly. A fact that nature has a waterfall or other type of water flowing into the place. With today's technology, the energy of water flow along the energy difference in elevation with a particular area (where the installation will be built) can be converted into electrical energy.

PLN electricity customers in 2011 in North Maluku reached 130.985 customers with connection power of 123.6 MVA and electricity sold reached 209 GWh. The largest electricity users is in Ternate city with usage share reached 49% of total electricity use in the province of North Maluku. By sector, the largest electricity usage is the household sector with a share of 65% followed by the business sector (17%), government (14%), social (3%) and industrial (1%). By looking at the composition of the electricity usage of this it is seen that the process of industrialization in North Maluku especially in the West district of Halmahera has not runned.



Picture 1. Power Plant Location Map in North Maluku (Source: North Maluku RUED report, 2014)

The electricity system in North Maluku province consists of 7 (seven) large electrical system that is the system of Ternate, Tobelo, Jailolo-Sofifi (West Halmahera), Soa-Sio (Tidore), Bacan, Sanana and Daruba. In addition, there are 21 units of small plants scattered. Based on the survey data on the Department of Energy and Mineral Resources of North Maluku province, hydropower potential is projected around 12.65 -17.10 MW. Potential can only be used as Micro Hydro

Power Plant and Mini Hydro Power Plant (micro power plants) with the capacity per unit generating around 500 kW to 2 MW.

The potential of water energy in the province of North Maluku contained in several regions including in Ibu Village, West Halmahera. Hydropower potential has been exploited is still relatively small. The utilization of hydropower proficiency level is still relatively small because the potential is usually located in remote areas that electricity demand is relatively small so for micro hydro potential are located far from consumers has not been utilized.

1.2. Literature Review

A. Definition of Micro Hydro Power

The definition of micro hydro power plant. Micro-hydro is a term that used for power plants that use water energy. Water conditions that can be utilized as a source of power (resources) is a power producer that has the capacity and the flow of a certain height and installation. Small power plant using hydropower in irrigation canals and natural rivers or waterfalls, by utilizing high waterfall (head, in m) and the amount of water discharge (m^3/s). The greater capacity of the flow and height of installation the greater the energy that can be harnessed to generate electricity.

Micro hydro power plant is generally a power generation type of run of river where the head is obtained not by building large dams, but by diverting the river water flow to one side of the river further subjecting it again to the river at a place where the necessary height difference has been obtained. Water supplied to the power house (house plants) which are usually built on the river bank. Water will rotate the turbine blades (runner), then the water is returned to the river of origin. Mechanical energy from the turbine shaft rotation is converted into electrical energy by a generator. Hydroelectric power plants under 200 kW are classified as micro hydro power plant.

Micro-hydro is just a term. Whereas micro means small hydro means water. In practice this term is something that is not standard, but micro-hydro, would use water as a source of energy. The difference between micro-hydro with a mini hydro power output is generated. Micro hydro power can result in lower than 100 W, while the mini-hydro power output ranges from 100 to 5000 W. Based on the output generated hydroelectricity distinguished by:

1. Large-hydro: more than 100 MW
2. Medium-hydro: between 15-100 MW
3. Small-hydro: between 1-15 MW
4. Mini-hydro: power above 100 KW, but less than 1 MW
5. Micro-hydro: The resulting output ranges from 5 KW to 100 KW, typically used to supply energy for small communities or rural communities are remote or difficult to reach.
6. Pico-hydro: power output ranging from hundreds of watts up to 5 KW

Micro-hydro power plant is a plant that produces electricity up to 100 KW while for a power plant that produces electricity of 100 KW-5 MW is defined as electricity generation. Technically, micro-hydro has three main components: water (source of energy), turbine and generator. Water flowing with a certain capacity at a certain height channeled towards the house installation (casing). At home installation, the water will strike the turbine where the turbine will receive the water energy and convert it into mechanical energy in the form of rotation of the turbine shaft. The rotating shaft is then transmitted to the generator using the clutch. Of the generator will produce electricity that will go into the control system of an electric current, before being discharged into homes or other purposes (load). That briefly micro-hydro change process flow and water level energy into electrical energy.

B. Micro Hydro Technology

A hydro scheme requires two things: water flow and height of fall (so-called 'head') to produce useful energy. It is a power conversion system, absorbing energy from the shape and height of the flow, and channel the energy in the form of electric power. Actually there is no power conversion system that can send power absorbed partially reduced the power lost by the system itself in the form of friction, heat, noise and so on.

Conversion equation is:

Input power = Output power + Loss (loss) or

Output power = Power supplied H conversion efficiency.

The above equation is usually used to describe differences were small. Input power or total power absorbed by the hydro scheme is dirty or Pgross. Power to the benefit delivered is clean power, or Pnet. All the efficiency of the scheme Pnet = Pgross H Eo kW.

Power is filthy dirty head (Hgross) multiplied by the water flow (Q) and multiplied by a factor (g = 9.8), so that the basic equation of power is:

Pnet = Pgross HH H Q Heo kW, where (g = 9.8)

Where head in meters, and the water flow in cubic meters per second (second/s). and Eo is divided as follows:

Eo = Econstruction civil, Epenstock H, H Eturbin, Egenerator H, H Esistem control, Elink H, H Etrafo. Usually E civil construction: 1.0-(channel length H 0002~0005)/Hgross E penstock: 0.90~0.95 (depending on length), E turbines: 0.70~0.85 (depending on the type of turbine), E generator: 0.80~0.95 (depending the capacity of the generator).

E control systems: 0.97, E network: 0.90~0.98 (depending on the length of the network), E transformer: 0.98E civil construction and E penstock is commonly reckoned as 'head loss (Hloss)/loss of altitude'. In this case, the above equation was changed to the following equation.

Pnet = g H (Hgross-Hloss) HQ H (Eo E civil construction E penstock) kW. This simple equation must be remembered because this is the essence of all the design work of the power plant. It is also important when using large units.

1.3. Research Method

A. Approach Method

This type of research is a quantitative research through a case study approach (case study). This study tried to design a micro hydro power with a capacity of 500 watts. Micro hydro power will be used to help the community in terms of providing electrical energy household.

B. Research Location and Time

The research location is in Ibu village, West Halmahera, North Maluku. The location of research is one of the factors that determine the feasibility of construction. The existence of micro hydro power will also provide the social, economic, environmental, and surrounding communities. Design and manufacture prototypes of micro hydro power is done in engineering lab and Mechanical Engineering workshop, University of Khairun, Ternate. As for the time of the study (manufacture and testing and application) is eight (8) months, starting from the month of May to December, 2016.

C. Tools and Materials

The material used in the design of the MHP are:

1.Laptop Cor i3
2.Personal Computer Pentium 4
3.MHP prototipe with technical specifications, as follows:
   a. Ponton
      Materials : Fiberglass
      Thick : 3 mm
      Heavy : 8 kg
   b. Frame windmill
      Materials : Angle Iron 3x3x1,5 mm
      Heavy frame : 8 kg
   c. Wheel water 12 blades

Materials : Steel Plate ST-37
Thick : 0,5 mm
Blade models : Blade
The number of blades : 12
Wheel weight : 76 kg

d. Gearbok 1:26
Materials : Steel
Heavy wheel : 56 kg

e. Poros
Materials : SC-45
Diameter : 2,5 mm

f. Bearing
Materials : Carbon Steel
Type : Ball Bearing
Bearing Number : ASB-UCP 205

g. Generator permanent magnets
Models : Ne-500 m^2
Rated Power : 500 Watt
Maximum Power : 536 Watt
Rated Voltage : 12/24/48 Volt
Rated Rotation Speed : 600 Rpm
Top Net Weight : 6,1 Kg
Start Torque : 0,42 Nm

h. AVR (Automatic Voltage Regulator)
AVR used to control the output voltage of the alternator to be stable in the battery charging.

i. Converter
Converter used to convert the DC voltage into AC voltage with a capacity of 1000 Watt

j. Baterai
Voltage : 12 Volt
Current : 32 Ampere

k. Multitester, used to measure the current and voltage generated by the alternator.

l. Tachometer, is used to measure the spin turbines and alternators.

m. Cabel and lights as well as workshop tools: screwdrivers, pliers, wrenches, hammers and others.

D. Data Collection Technique

Data was collected through:

1. Observasi and observations directly to the location of the research, conducted to obtain primary data related to various aspects, such as: water discharge, high drops and water flow, voltage and current of water.
2. Literature review as a basis for studying and designing the micro hydro power.

D. Data Analysis Technique

The data obtained from the data collection are used to analyze and design the micro hydro power. The technical analysis of the data include:

1. Make the basic concepts of design micro hydro power planned to gain power. The power is analyzed to obtain the size of the wheel diameter and width in accordance with the planned power.
2. Design process, plan everything that is related to the micro hydro power technical calculations and the variation amount windmill blade.
3. Simulation using ANSYS 14.5 software. Windmills simulated is windmill blade 12 at a flow rate of water that has been determined in advance.
4. Real Experimental by making real prototypes of MHP and tested in the study site then the real test data were compared with design data and simulation results.

1.4. Results and Discussion

MHP design process begins from planned power then calculate how big the size and shape of the optimal waterwheel blade. Once a model windmill and windmill capacity obtained then making a complete wheel models. Windmills are planned and designed by using pontoons and floating with GMP as a producer of electric current. To get results as planned, then the windmill blades rotate GMP but not directly connected using a 1:26 gearbox so that a maximum rotation GMP can be achieved optimally.

Basic selection is GMP in micro hydro power:

1. GMP low speed

2. Round windmill generated very low at 2-12 rpm
3. Maintenance is easy
4. Ethnic spare a lot on the market

Micro hydro power is designed using software that uses a few:

1. AUTOCAD 2010 program used to design working drawings PLTMHT
2. Program SOLIDWORKS 2011 is used for 3-dimensional image mendesai PLTMHT and Geometry object.
3. Program ANSYS 14.5 is used to simulate the flow of water striking the blades of the mill, to find the amount of torque produced by the windmill.

A. Micro Hydro Power Working Principle

Micro hydro power working principle is to utilize the flow and speed of the water flow in the river. The water flow will rotate turbines that will generate mechanical energy. This mechanical energy is going to turn a generator to produce electricity. The amount of power or kinetic energy generated by the flow of water is:

$$E=\frac{1}{2}m \text{ x } v^2$$

Where v is the velocity of water flow (m/s), which provided water power is expressed as follows:

$$P=\frac{1}{2}\rho \text{ x } A \text{ x } v^3$$

A is the cross sectional area of the flow of water (m^2)

Where:

P = Power (watts)

Q = flow capacity (m^3/s)

ρ = Future types of water (kg/s^3)

B. Micro Hydro Power Components

Components used in the MHP both major components and supporting components include:

1. Ponton

The pontoon is designed using the principle of archimedes that the object is dipped into liquid will experience upward force (buoyancy force) is equal to the weight of liquid displaced by the object).

$$F_a= \rho_a \text{ x } V_a \text{ x } g$$

Where:

Fa = Force To Top Benda (N)

ρ_a = Massa Type Fluid (1000 Kg/m^3)

Va = Volume of water pressed (m^3)

g = Acceleration of Gravity (m/s^2)

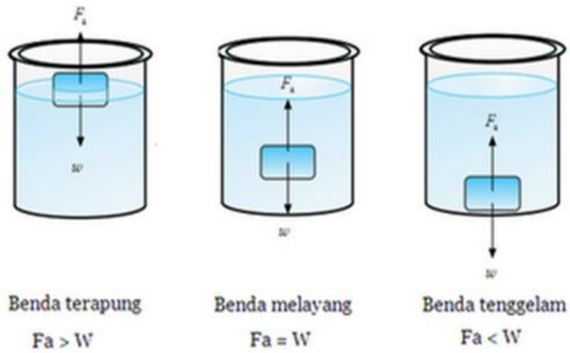


Figure 2. Floating Objects, Floating and Sinking (Source: Buoyancy, 2011).

In figure 2 a floating object when Fa> w, objects float if Fa = w, or objects sinking if Fa<w, is the principle of the law of archimedes, which is an object to be floating, sinking or floating in a liquid depends on gravity and upward force.

1. The object will float if the density of objects in the water less than the density of a substance melting (1)
2. The object will float if the density of objects that exist in the same water with the density of their liquid substances. (2)
3. The object will tenggelam if the density of objects in the water is greater than the density of a substance melting

Based on the weight of displaced water can be determined by the following equation.

$$W_D= \rho \text{ x } g \left(V_{ip} + V_{iT}\right)$$

Where g is the gravity, is the future of water (kg/m^3), Vip is the volume of the submerged pontoons and Vit is a volume wheel dipped and accessories. Thus the number of the buoyancy pontoons can be calculated using the following equation:

$$F_A= W_D$$

So that the weight of the water mill and its accessories can be determined using the following equation:

$$W_T = W_{TUR} + W_{PON} + W_{PR}$$

Where W_{TUR} is the weight of the turbine, W_{PON} is the weight of the pontoon, W_{PR} is the weight of the other elements in the system. Requirements to make the system micro hydro power can be obtained by:

$$W_{TUR} + W_{PON} + W_{PR} \leq \rho_{WATER} \times \left(V_{ip} + V_{iT}\right)$$

Number of drag force is proportional to the field directly interact with the water system, the speed in the water and the number of windmills. So that the force acting can be modeled as:

$$F_D = 0.5\, \rho\, (V_{WATER})^2 x\, (A1_{PON} + A1_{Turbin}) + F_T$$

Where V_{WATER} is the speed of the river/irrigation, $A1_{PON}$ is part of the sinking of the pontoons, $A1_{Turbine}$ is part of the water wheel that is sinking in water and F_T is the buoyancy thrust turbine.

2. Water Mill

Design waterwheel begins with determining the shape of windmill using pontoons and GMP as producing electricity. To get the desired results, then planned windmill does not directly play GMP, but using the maximum rotation GMP gearbox that can be achieved. Round mill ranged from 5-12 rpm, if more than the so-called turbine. The planned windmill type undershot by the number of blades as much as 12 blade, a model windmill can be seen in the picture below.

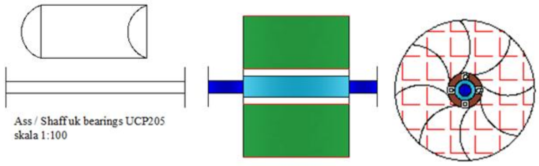


Figure 3. Model Micro Hydro Power Planned Windmills
(Source: Researcher, 2016)

This windmill bekarja when water flows, hit the wall of the blade located on the bottom of the waterwheel. Undershot waterwheel suitable type mounted on watersheds and irrigation. Waterwheel power generated comes from the kinetic energy of the water (water flow), if the water flow is directed to a field, theoretically the field or the wall will receive the force due to the impact of water against a wall or the field. If the wall is mounted on a (wheel) then the force of the collision on the wall will cause the torque that will cause the wheel spins on its axis. The amount of torque generated by the collision of water directly related to:

1. Speed of water flow
2. The size of the wall or the field collision
3. The diameter paddle wheel
4. Water discharge

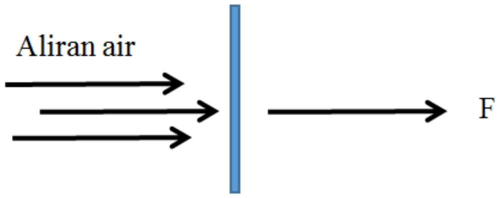


Figure 4. Flow Flowing Water On Wheels Wall (Blade) Windmill
(Source: Yusri, Aidil Zamri, 2012)

In the above picture portrait of flowing water is formulated as follows:

$$Q = V.A$$

While the volume of the blade a quarter of the pipeline are:

$$A = b \times h$$

Where:

b = area of the blade (m)
h = length of the blade (m)

Radius around the windmill can be calculated using the following equation:

$$K = \pi \frac{(R-r)^2}{\sqrt{2}}$$

While heavy mill can be calculated using the equation:

$$\text{Massa } (m) = \pi \frac{(R-r)^2}{\sqrt{2}} A \,.\, \rho$$

The magnitude of the moment of inertia (I) turbines are:

$$I = m K^2$$

Where:

K = Radius wheel circumference (m)
m = Time pinwheel (kg)
r = The radius of the inner wheel (m)
R = The radius of the outer wheel (m)
T = Torque (Nm)

I = Moment of Inertia ($Kg.m^2$)
If the wall has a rotary axis of the blade as shown below:

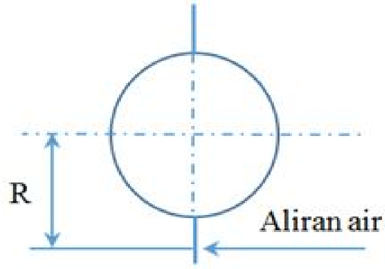


Figure 5. Water Wheel
(Source: Yusri, Aidil Zamri, 2012)

Then the amount of torque generated from the rotary axis turbines can be calculated by the following equation:

$$T = F.\ R \quad (14)$$

Because the wall can rotate on its axis it will cause peripheral speed at the end of the wall of the U. will thus result in the wheel peripheral speed.

$$U_1 = 0.5\ V_1 \text{Cos}\ \alpha \quad (15)$$

Where:
U = Kecpatan wheel circumference (m / s)
V = Kecpatan water flow (m / s)
α = blade angle in degrees
So that the accepted style windmill is:

$$F = m\ .\ V \quad (16)$$

Where:
F = force at the wheel (Newton)
While the wheel peripheral speed (U) theoretically have a relationship approach to water flow velocity (V), in which the peripheral speed of wheel angle.

$$\omega = \frac{U}{R} \quad (17)$$

Where:
ω = Peripheral speed wheel angle (Rad)
While the wheel rotation can be calculated by the following equation:

$$N = \frac{60\ .\ U}{\pi\ .\ D}\ \text{(rpm)} \quad (18)$$

Then the mill wheel power generated can be calculated with the following equation:

$$P = T\ .\omega \quad (19)$$

While the GMP or alternator power can be calculated by the following equation:

$$P_d = V\ .\ I \quad (20)$$

The planned amount of power is power multiplied with the GMP or alternator power factor correction.

$$P_r = f_c\ .\ P_d$$

From the planned power can be calculated magnitude of the torque shaft, to determine how large diameter shaft that will be used, using the following equation:

$$T = 9.74 \times 10^5 \frac{P_d}{N}$$

Specifications shaft material can be selected from the stem S45C carbon steel cold-D Difinising Japanese standard (JIS), which basically is often used for the shaft.
By knowing the specifications of the shaft material, it can be calculated shear stress permits, (τa) ie:

$$\tau a = \delta b / (sf_1 x sf_2)$$

Shaft diameter (ds) to be designed can be calculated using the equation:

$$d_s = \left[\frac{5.1}{\tau a} K_t C_b T\right]^{\frac{1}{3}}$$

Where:
Kt = 1.5 loads imposed by shock or collision
Cb = 1.45 occurs usage with bending loads
T = Torque

The transmission system is planned to use gearbok with 1:26 gear ratio, gearbok can forward rotation and power are more varied and more compact than using other means of transmission, in addition to the gear also has several advantages when compared to other transmission apparatus, namely:
1. Transmission system more compact, higher rounds and a great power.
2. The system is compact so the simple construction.
3. The ability to accept a higher load.
4. High efficiency transfer of power because of the very small slip.
5. The transmission speed gears can be determined so that it can be used with measurements of small and large power.

In theory, the gear is generally regarded as a rigid body almost unchanged form in the

long term. The characteristics of straight gears are:
1. Power is transmitted <25,000 Hp
2. Round transmitted <100,000 rpm
3. The peripheral velocity <200 m/s
4. The ratio of the speeds used
   * For the first level (i) <8
   * For the second level (i) <45
   * For the third level of (i) <200
   * (i) is the speed comparison between the mover with driven
5. The overall efficiency for each level of 96% -99% depending on design and size.

Theoretically size gear wheel depicted with circles (pitch circle) memilikidiameter (pitch diameter) smaller than the diameter of the whole gear for gear teeth intersect (overlap). The distance between the teeth of the gear and Other critical one is called the circular pitch. Number of teeth on a gear can be determined by the formula:

$$N = \frac{\text{Keliling gir}}{\text{Jarak antar gigi}} = \frac{\pi \text{ x } D}{P_c}$$

Where:
N = Number of teeth
D = Pitch diameter
Pc = Circular pitch

Gear ratio is the ratio of the number of teeth on the two gears, two gears on the image 2.9gir pengerak have 10gigi gear-driven and have 260 teeth, the gear ratio is 10/260 = 1; 26 to mentautkan two gear we need to consider is the size of the gear teeth should be the same, in other words, both must have the same number of teeth on each gear inch circumference. So gear ratio is also the ratio of the circumference of gear, so that the equation to be like this.

$$N_g = \frac{N_2}{N_1} = \frac{Kel_2}{Kel_1} = \frac{\pi \text{ x } Dia_2}{\pi \text{ x } Dia_1} = \frac{Dia_2}{Dia_1} \quad (26)$$

Where:
Ng = Ratio gir
N = Number of teeth
Kel = Roving gear (mm)
Dia = Diameter gear (mm)

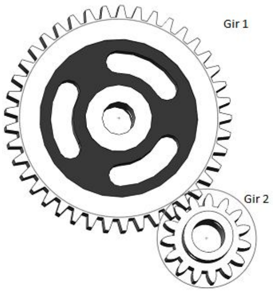


Figure 6. Gir Straight/Spur Gear
(Source: Documentation Researcher, 2016)

In the picture above it is assumed that the gir gir 1 is a mover or gear that provides power, while the second gear is overdrive to receive power or gear driven. If there is a 1 gear ratio and two overdrive at 1:26, this means that the gear 1 will rotate one full and two rotating gears as much as 26 times, this means also that the gear 2 rotates 26 times faster than the next compares gir 1. Equation the gear ratio to the speed spinning gear.

$$N_g = \frac{N_2}{N_1} = \frac{\theta_2}{\theta_1} = \frac{\omega_2}{\omega_1} = \frac{\alpha_2}{\alpha_1} \quad (25)$$

Where:
Ng = Ratio gir
N = Number of teeth
θ = Gear position (angle in degrees)
ω = Angular speed gear (rpm)
α = Acceleration angular gear (rpm)

Here are some pieces of the terms you need to know in the design of the gear you need to know are:

1. Pich Circle
   The imaginary circle rolling without occurrence of slip. This circle is the basis to provide measures such as thick dental teeth, spacing between teeth and others.
2. Pinton
   The smaller wheel teeth in a pair of gears
3. Pitch Circle Diameter
   It is the diameter of the circle
4. Diameter Pitch
   The number of gear pitch diameter unity
5. Circular Pitch

Distance along the pitch circle between two adjacent tooth profiles or pitch circumference of a circle divided by the number of teeth, in the formula can be written:

$$t= \frac{\pi d_{b1}}{z}$$

6. Module
Comparison between the pitch circle diameter by the number of teeth.

$$m = \frac{d_{b1}}{z}$$

7. Addendum
The distance between the circular head with a pitch circle with a circular pitch measured in the radial direction.
8. Dedendum
The distance between the pitch circle with the circle foot measured in the radial direction.
9. Working Depth
Number of head radius of a pair of gears that contact is reduced with distance of shafts
10. Clearance Circle
Circles are tangent to the circle addendum of tooth pairs
11. Pitch Point
The point tangent of the pitch circle of the gear pair are in contact roomates IS ALSO a point of intersection between the line and the center line of work.
12. Operating pitch Circle
Circle circle tangent of a pair of gears in contact and distance axis deviates from the theoretically correct axis distance
13. Addendum Circle
Circle of head gear that limits the circle of teeth
14. Dedendum Circle
Circle the circle foot gear that limits foot gear
15. Width of Space
Thick space between gears measured along the pitch circle
16. Pressure Angle
The angle formed from the normal line to the tilt of the head gear
17. Total Depth
The amount of the addendum and dedendum
18. Tooth Thickness
The width of the teeth measured along the pitch circle (28)
19. Tooth Space
The size of the space between two teeth along the pitch circle
20. Backlash
The difference between the thick teeth with wide space (29)
21. Face of Tooth
The surface of tooth above pitch circle
22. Flank of Tooth
The surface of teeth below the pitch circle
23. Top Land
The surface at the cusp
24. Face Width
The depth measured parallel axis gear

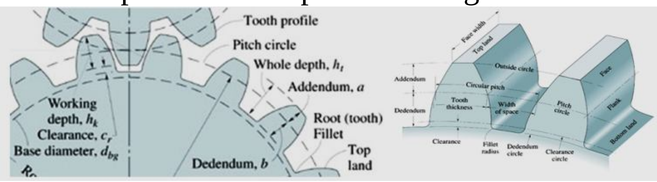


Figure 7. Parts Of Gear Cone Straight (Source: Supreme D, Marsis W.P. 2013)

Formulas commonly used in the design of the gear straight

• Style Ft working in the direction of rotation of the gear:

$$F_t = F_n \ x \ \cos \alpha \ b$$

Where:
Ft: Style tangential
Fn: Normal pressure on tooth surfaces
αb: working pressure angle

• If the diameter is the distance for db1 (mm), the circumferential velocity v (m/s) in the circle for the distance of the gear having a rotation N_1 (rpm) is:

$$v = \frac{\pi \ x \ Dd_1 x \ N_1}{60 \ x \ 1000}$$

• The relationship between the transmitted power P (kW), tangential force Ft (kg) and a peripheral speed v (m/s), are:

$$P = \frac{Ft \ x \ v}{102}$$

If b (mm) is the width of the side, BC = h (mm), and AE = L (mm), then the bending stress σb (kg/mm^2) at points B and C (which size penampangnya dalah bxh), with a load of style tangential Ft.

• Expenses tangential force Ft at the height of the beam:

$$\sigma b = \frac{Ft \times L}{b \times (\frac{h^2}{6})} \tag{33}$$

$$Ft = \sigma b \times b \times \frac{b^2}{6L} \tag{34}$$

• authorized bending stress σa (kg / mm2), the amount depends on the kind of material and heat treatment are:

$$\sigma a = \frac{F_b}{M \times Y \times Fv} \tag{35}$$

Where;
Fb = Bending load (kg / mm)
Y = Factor tooth shape
Fv = Dynamic factor

As in the calculation of bending, the load surface which allowed wide unity F1H (kg/mm) can diperleh of KH, d1, Z1, Z2, Fy in the equation:

$$F^1{}_H = F_v \times K_H \times d_{01} \times \frac{2\,Z_2}{Z_1+Z_2} \tag{36}$$

Where:
K_H is a stress factor Contact
D_1 is the diameter of the circle distance
Z_1 is the number of gear teeth 1
Z_2 is the number of gear teeth 2

• Contact voltage factor that allowed the gears are:

$$K = 2 \,.\, F_V \,.\, K_H \tag{37}$$

• As in the calculation of bending, surface load permitted wide unity F1H (kg / mm) can be obtained in the equation:

$$F^1{}_H = F_v \times K_H \times d \times \frac{2\,Z_2}{Z_1+Z_2}$$

3. The permanent magnet generator (GMP)
GMP is a tool used to convert mechanical energy (mechanical) into electrical energy. GMP planned is the type of low speed with the following specifications:
Permanent magnet generator

1. Model : Ne-500 M^2
2. Rated power : 500 Watt
3. Maksimum power : 536 Watt
4. Rated voltage : 12/24/48 Volt
5. Rated rotation speed : 600 Rpm
6. Top net weight : 6.1 Kg
7. Start torque : 0.42 Nm

4. Accumulator
The battery is a power tool that stores energy chemically and issued in the form of electricity. Battery voltage on the market and using liquid electrolyte is 12 Volts and there is also a 6 Volt. For this type of dry battery output voltage of 1.5 - 12 Volt. Normal stress from a 12 Volt battery is 12.6 Volt. The battery consists of cells, each cell voltage of about 2.1 volts. For a 12 Volt battery using a 6 cell. Each cell consists of a plate of positive and negative plates separated by a separator to avoid direct relationship. All the positive plates are connected together by a plate strape so that it becomes part of the plate so well positf negative plates are connected by plate strape so that a negative plate.
Inside there is a battery electrolyte is a mixture of sulfuric acid and water. Each cell battery is placed on the box separately and connected to one another by the connecting rod. Material from the positive plate is brown while the negative plate active material is gray. Electrolyte (H2SO4) or cairanya is a mixture of sulfuric acid and water (H2O).

Figure 8. Battery 32 Ampere
(Source: Documentation Researcher, 2015)

5. Converter
DC to AC converter working to change the input DC electricity into AC electricity output and a large symmetrical with the desired frequency.

The voltage output can be specified and may also vary with the particular frequency or frequency altered.

6. Supplies mooring ropes anchoring
   Supplies mooring ropes anchoring PLTMHT using Φ20 mm with a length of 50 meter rope tied on an anchor mooring equipment that is planted in the ground or tied to an object.

Figure 9.Tali Nylon

(Source: Documentation Researcher, 2015)

Conclusion

Potential water resources are abundant in Indonesia because of the presence of many tropical rain forests, making us to be able to develop this potential, because water is a renewable energy source and natural. If this can continue to be explored, the conversion of water into electrical energy is very beneficial for the country. In Indonesia there has been a lot of MHP and reservoirs to store water, just how we can develop the MHP became better and more efficiently.

Increased need for power supply to the rural areas in a number of countries partly to support industries and partly to provide illumination at night. The ability of the government was deterred by the high costs for the expansion of the electricity network, can create micro-hydro as an economic alternative to the network. This is because the independent micro hydro scheme can save you from the transmission network because the network expansion schemes usually require equipment and employee costs are expensive. In the contract, micro-hydro schemes can be designed and built by local employees, and smaller organizations, the following rules are more loose and use of local technologies, such as for irrigation work traditional or locally made machines. This approach is known as a local approach.

Waterwheels on MHP which is designed not to be too light so that the water wheel was not swayed by the waves arising from the moment paddle wheel and can move to the left and to the right. MHP windmill design should be balanced between the buoyancy and its pontoon capacity. MHP water mill during operation should be monitored for the following aspects.

1. The permanent magnet generator is not resistant to water, so that when submerged in or splashed by rain water quickly broken, so it needs careful maintenance and upkeep.
2. The permanent magnet generator low round is currently not produced in the country, therefore, must be imported. In connection with it, the price of low round alternator is quite expensive because of a tax and duty-entry. Therefore, it has to be maintained for not loosing it.
3. Leaks in the pontoons can result in skewed MHP and unsinkable, therefore need continuous supervision so that it does not happen.
4. When the MHP operates waterwheel spins can be disrupted because of the garbage that passes from the filtration, so that the MHP may be interrupted or even stopped. It required care and supervision.

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