Performance Analysis of Submerged Vehicle Electric Propulsion with DC Motor 2x1850 kW 380 Volt which Supplied Power 10260 AH on 190 VDC in Series and Parallel Circuits

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***Abstract*—an electric DC motor that is used as a main propulsion, typically used on ships with high maneuverability, special ships, ships wtih great cargo load, and the ships that use prime movers non-reversible (generally using a gas turbine, steam turbine and high-speed diesel in its use is unlikely to reverse its rotation quickly). As for the expected results we will obtain the characteristics (such as torque and rotation) on a series DC motor series and in parallel on the propulsion system, determines where an efficient circuit for the propulsion system, getting long use of batteries used for such needs. In this research will be assessed numerically by simulation using MATLAB-Simulink the drive system by using a DC motor in a vehicle submerged was carried out together series and parallel. The result obtained is the same input voltage of 190 Volt same torque value of 140 Nm is generated at the motor circuit series and parallel. So that a series circuit, generating a service speed of 12 knots and 21.5 knots using a converter, and usually when submerged condition in the sea. For parallel circuit produces speed of 14 knots and 11 knots using a converter.**

Keywords—DC motor, matlab-simulink, propulsion system, torque

I. Introduction

The electrical propulsion system is systems on ships using electrical machines AC or DC the performance of the main engine, which in this case the generator is connected to a switchboard, and further energy or electric current is passed to the transformer, then converted using konventer to electric motors which drive the ship's propeller. In general, the ship that has special utility that uses a DC motor and for profit-oriented commercial ships generally use AC motors.

DC electric motor that is used as a main propulsion, typically used on ships with high maneuverability, special ships, ships with great cargo load, and the ships that use prime movers non-reversible (generally using a gas turbine, steam turbine and high-speed diesel in its use is unlikely to reverse its rotation quickly). The development of a prime mover for main propulsion on board experienced rapid growth since the invention of the steam by J. Watt, by Rudolf Diesel diesel engines and gas turbines by Brayton. Things that need to be considered in the use of a DC motor as the actuator is matters related to electric motors, among others, the initial flow, the speed setting method, the method of reversal rotation, braking and others. In the early years of the discoveries about the three prime movers only revolve around the improvement of the working system. For example, icebreaker (ice breaker) uses a DC motor in this case due to the required torque very large propeller.

There are three ways to regulate rotation in a DC motor including a magnetic flux arrangements, armature resistance arrangement , as well as the terminal voltage regulation [1].

As for the expected results we will getting characteristics (such as torque and rotation) on a DC series motor and in parallel on the propulsion system, determines where an efficient circuit for the propulsion system, the long usage of batteries used for such needs.

Things that need to be considered in the use of DC motor as the actuator is matters related to electric motors, among others, the starting current, the speed setting method, reversal method rounds, etc. There are three kinds of methods to regulate the rotation of the DC motor, one of which is to control the terminal voltage. In the electric propulsion system, it takes some variation of the circuit to match needs with rotation speed generated by DC motor [1].

The most advanced vehicles submerged make their own fresh water from sea water. There is also a reserve of air to the process of liberating oxygen from freshwater. Although the vehicle submerged float with ease, the ship was able to dive to the ocean floor and remained there until months long. The secret lies in the double wall construction typical of the ship. Special spaces watertight (or ballast tank) between the outer wall and inner wall can be filled with sea water thereby increasing the overall weight and reduced buoyancy.

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Resistance are the forces that hinder the pace of the ship. These resistance include:

a. The force perpendicular to the hull (the normal force)

b. The force tangent to the hull.

In designing a new ship, the very thing that influenced the design of the vessel:

a. buoyancy

b. Stability

Total Resistance submerged vehicle can be formulated as follows:

$$R_T = R_{BH} + R_{APP} \quad (1)$$

Where R_T is the total resistance of ship, R_{BH} is the hull resistance and R_{APP} is the additional resistance (such as contol surfaces, the condition of shipping)

While to calculate $R_{BH,}$ the formula is presented on equation (2)

$$R_{BH} = \frac{1}{2}\rho A V^2 C_T \quad (2)$$

Where, ρ is density of sea water, A is the large of areas can use formula L^2, V is the speed service of ship. Equation (3) present the formula to calculate the coefficient of total ship resistances.

$$C_T = Cf + \Delta Cf + Cr + Cw \quad (3)$$

$$Cf = \frac{0{,}075}{(\log Re - 2)^2} \quad (4)$$

$$Re = \frac{V \times L}{v} \quad (5)$$

ΔCf = between 0,0004-0,0009

The advantage in the use of electric propulsion systems when compared with other propulsion systems is the initial investment that is not too big, save space, lighter and less loss of power in the transitional system compared to other propulsion systems. Electrical connections between generators and propulsion motors more flexibility in laying equipment in the room. Moreover, it can use a variety of prime movers such as diesel, gas turbines, steam turbines, and its output can be more easily incorporated than the mechanical system. For the type of prime movers indirectly, electric drive has the advantage could reverse rotation propeller with relatively easy control.

The disadvantage of the electric propulsion system, namely in terms of the sound or noise of the ship, it is the absence of explosion or combustion in the electric motor, the motor propulsion system is not too intrusive in terms of sound. In addition, efficient electric propulsion system only at maximum power, when compared to diesel engines. Require extra caring, larger and more expensive, not suitable for high speed applications and is not suitable for large power applications.

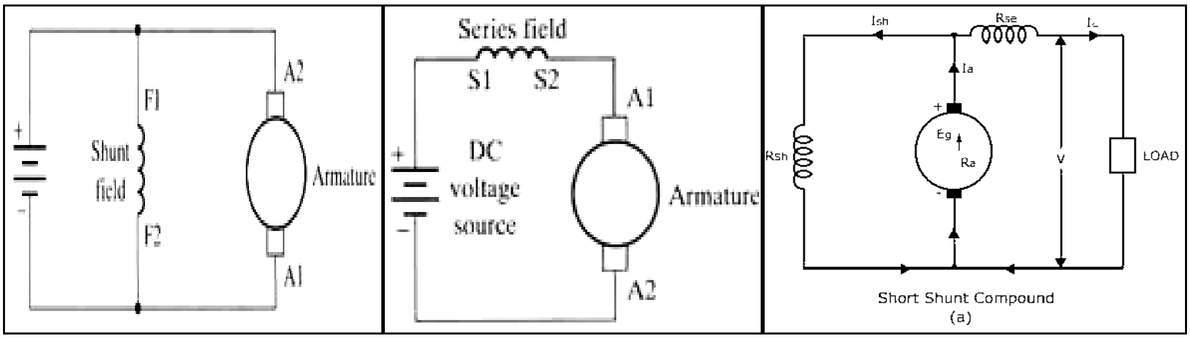

Figure. 1. Type of DC motor

The electric motor is an electromechanical device that converts electrical energy into mechanical energy. This mechanical energy is used for, for example, rotate the pump impeller, fan or blower, drive the compressor, lifting materials, and sebagaianya. DC motors are motors that require a supply voltage in the same direction on the field coils and coil anchor to be converted into mechanical energy. Field coil in the dc motor called the stator (the part that does not rotate) and the anchor coil called a rotor (rotating part).

Figure 1 is a picture of the series of DC motors. Type of DC motor based on connection: series, shunt, and compund.

DC motor control to regulate the terminal voltage using Ward-Leonard. This type of arrangement is commonly used in the industry which has rolling (rolling process) such as, paper industry, industrial steel plates, etc. With some modifications, this method can be applied in particular to the ship electric propulsion system on board. Ward-Leonard system is more than just a simple way to implement a variable dc to dc armature of the motor. It really can force the motor separately develop torque and speed required by the load.

DC power system usually consists of several rounds of high or medium generators that are arranged in parallel. Selection of the size of the engine based on the operating level that allows multiple operating units does not exceed the total power generated. To obtain optimum power, generators usually have a generator at two different rounds. The resulting electrical current generator is connected to the main terminal through the connecting circuit. This interface circuit is intended to connect and memutuskaan flows in the event of over-load and short-circuit. Often a circuit terminal system created to meet the power requirements on a vessel taken at the same terminal through a transformer or a motor generator.

To reverse the direction of rotation of DC motors are usually done on a fixed pitch propeller type, there are two approaches that might be used. The first is to reverse the direction of current flow in the motor field. The second method is to change the direction of the current anchor. DC electric drive systems are often fitted with a field shunt regulator that keeps the motor operating at constant power. Mechanically described as setting reduction gear ratio allowing the main engine to operate at engine speed changing. On large ships torque power an estimated 70% of propeller rotation rpm [2-8].

MATLAB (Matrix Laboratory) is a program for analysis and numerical computation and an advanced mathematical programming language built on the premise that using the nature and form of a matrix.

Initially, the program is an interface for collection of numerical routines of LINPACK and EISPACK project, and developed using the FORTRAN language but is now a commercial product of the company Mathworks, Inc.yang in the subsequent development was developed using C ++ and assembler language (primarily to-function MATLAB basic functions).

MATLAB has evolved into a sophisticated programming environment that contains functions built-in to perform the task of signal processing, linear algebra and other mathematical calculations. MATLAB also contain additional toolbox that contains the functions for specific applications.

MATLAB is extensible, meaning that a user can write new functions to be added to the library when those functions built-in available unable to perform certain tasks. Programming skills required is not too difficult if you have had experience in other programming languages such as C, Pascal, or FORTRAN

II. METHOD

In this research is used methodology to determine the purpose and the result. This research uses some methods. These following methods are: (1) Identification and Problem Formulation (2) Identification (3) Analyzing and Interpretation Data (4) Result.

A. Formulation of the problem

The first stages is to identify existing problems and then will look for solutions in this research.

B. Study Literature

Study Literature is a second step to do this research to looking for many references and analysis material. Those are shall accordance by confidence literature then help to do this research. Study Literature can take from sourch of references such as Book, Catalog, Journals, Papers, etc.

C. Data Collection

Data - the necessary data will be collected through a variety of ways, including the following:

 Primary data: primary data obtained from the variation rangakain DC motor on the circuit electrical propulsion system in previous research.

 Data Secondary: secondary data obtained from relevant journals, papers, books and the internet.

D. Systems Planning and Analysis

At this step of planning will be done analysis of any variations in the sequence of DC motors will be used for ship propulsion drive system, consisting of:

- Analysis of variations of the DC motor circuit
- Analysis on each circuit power requirement DC motors
- Analysis of the needs of current or amperage in each set of DC motors
- Analysis battery voltage generated at each circuit DC motors

At this step Matlab-Simulink software is used to convert from the motor circuit matlab series

E. Conclusion and Recommendation

Conclusion and recommendation made based all aspect of this research discussion.

III. RESULTS AND DISCUSSION

A. Principal Dimension

Table 1 shows the principal dimension of the ship. This data will be used for calculation.

B. Data of Propulsion System

In this research only the electric motor and batteries that will be discussed. Here is more information about batteries and electric motors used in these systems.

a. Electric motor
- Quantity : 1 piece
- Type : DL 380 V shunt motor, DC
- Power: 2 x 1850 kW at 200 rpm propeller rotation
- Construction: made double field

The main task of a DC electric motor is to move the ship (forward / backward) through an intermediary-flexible coupling (flexible coupling) to the propeller or propeller. Electric current obtained from the four batteries or obtained directly from the four diesel generators. Motor made double anchor that can be assembled series or in parallel when used depending on the desired stimulation based regime.

b. Battery

The specifications of the batteries used in the vehicle-unders are:
- Total: 480 cell, divided 4 groups (Groups I and II, R. Batt. 1 and Group III and IV in R. Batt. 2)
- Voltage: 2-3 volt / cell
- Capacity: 10 260 AH (27.5 kWh)
- Dimensions: (1421 x 290 x 450) mm
- Weight: 525 ± 2 kg

Placement of the battery is divided into 4 groups, each group was placed in a row 6 rows. Each line consists of 20 cells. Figure 2 is show of scheme of DC Motor in series circuit and paralel circuit.

TABLE 1.
THE PRINCIPAL DIMENSION OF SHIP

LOA	59.570 m
Load Length Press	45.159 m
Inner Diameter	6.2 m
Draft	5.5 m
Diving Displacement	1390 m^3
Diving Depth	250 m
Dive time speed	21.5 knot
Shipping distance	22 NM (80% Batt)

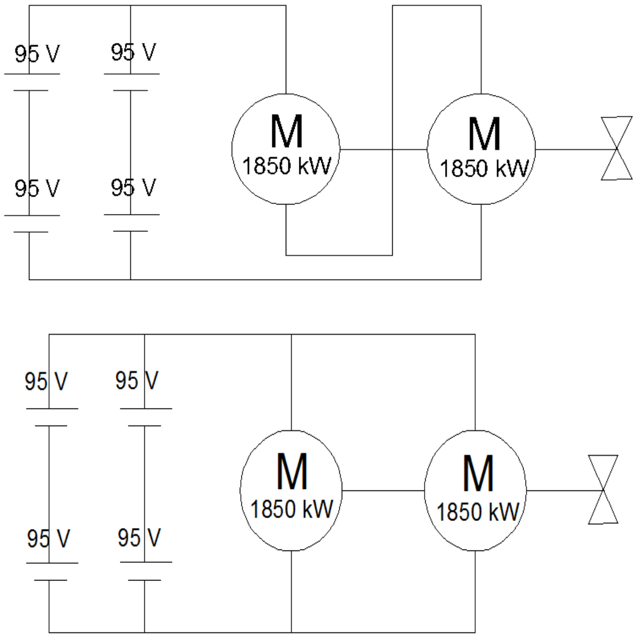

Figure. 2. DC Motor circuit scheme for ship propulsion

TABLE 2.
THE PRINCIPAL DIMENSION OF SHIP

Hull form	C_r x 10^{-3}
Deep Quest	0.677
DSRV	0.435
Fleet Submarine	0.39
Albacore	0.1

C. Detail Calculation

From the above data it can be calculated that resistance also influenced by the speed generated by a submerged vehicle. The following is the calculation of total resistance:

1. Calculation of the Reynolds number
   Here is a calculation to find the Reynolds number:
   Re = (V x L) / v
   = 172.863248
2. Calculation of Cf
   Cf = 0.075 / $(\log Re-2)^2$
   = 0.06198
3. Determining the value of correlative allowance (ΔCf)
   ΔCf has a value of 0.0004 to 0.0009
   So from the above statement is 0.0004
4. Residu Resistance determine (Cr)
   According to the table 2, taken value of 0.39 x 10-3 ie submarine fleet, then the Taken value of 0.39 x 10-3 ie submarine fleet, then the value of Cr is 0.00039 and albacore 0.1 x 10-3
5. Determining the value detainee Wave
   Due to its value is very small and depends on the desaigner then its value is ignored so 0
6. Calculating nondimentional drag coefisin
   Ct = Cf + Cw+ ΔCf + Cr
   = 0.06248
7. Calculating the value of Prisoners bare Hull
   RBH = ½ρAV²Ct
   = 101,730.1444 N
   = 101.7301444 kN
8. Calculating the value of additional prisoners (RAPP)
   Additional resistance value formula is the same as the RBH only distinguishing is the value Ct. For Ct at RAPP based on this Table 3
   So, Ct = 0,005
   So, R_{APP} = ½ρAV²Ct
   = 34190,37061 N
   = 34,19037061 kN
9. Calcukating Total Resistance (R_T)
   R_T = R_{BH} + R_{APP}
   = 101,7301444 + 34,19037061
   = 135,9205 kN

D. Calculation of Torque

1. Looking for EHP
   EHP = Rtdinas x V
   = 135,9205 x 21,5
   = 2922,29 kW
   = 3973.203 HP
2. Looking for DHP
   Is the power absorbed by the propeller of perporosan system or power delivered by the system perporosan to the propeller to be converted into thrust (thrust)
   DHP = EHP / Pc
   Where, Pc = ηH x ηrr x ηo
   • Hull Efficiency (ηH) (1-t) / (1-w)
   Wake friction or join current is the ratio between the speed of the ship with the speed of the water leading to the propeller. Using the formula given by Taylor, then obtained:
   W = 0.5Cb-12:05
   = 0.4070

   Values t can be sought from the value w is already known, namely:
   t = k.w

= 0.285

So ηH = (1-t) / (1-w) = 1,205

• value ηR for vessels with propeller-type single screw ranged from 1.0 to 1.1 then the value 1

• Efficiency Propulsion (ηo) is open water efficiency that is efficiency of the propeller at the time of open water test. Its value is between 40-70%, and taken: 40%

- Pc = ηH x ηrr x ηo = 0,4824

DHP = EHP/Pc

= 2922,29 kW

3. Looking for Torque

$$DHP = \frac{2x3,14xnxQ}{60}$$

From above formula $Q = \frac{DHP\ x\ 60}{2\ x\ 3,14x\ n}$ (ft lb)

Q = 102,37 ft lb = 139,599 Nm

TABLE 3.
THE VALUE OF CT

Appendage	Area Basis	C_t
Small domes	profile	0.015
Antennae	Projected	1.2
Cylinders	Projected	1.2
Arms	Wetted surface	0.005
Long faired protuberances	Wetted surface	0.005
Holes in skin	Projected frontal	0.5
Planes	Projected frontal	0.011

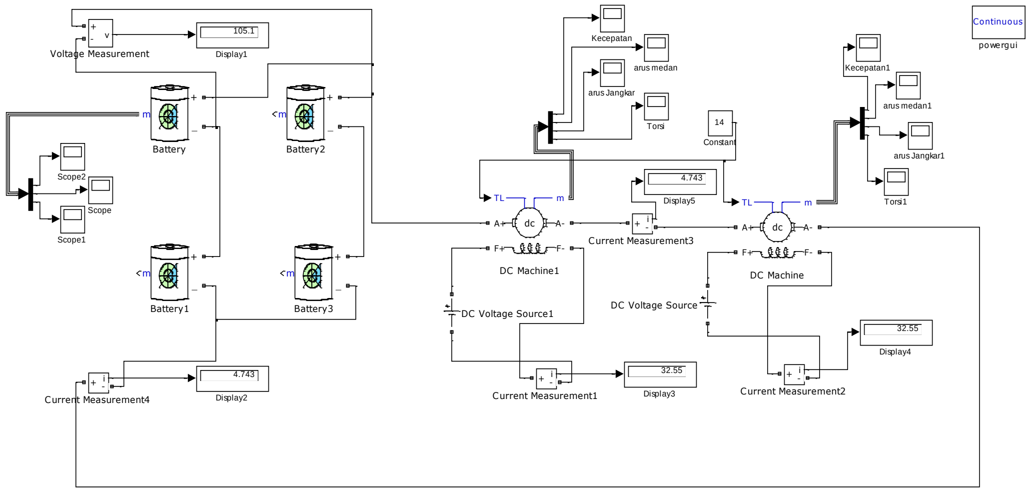

Figure. 3. Series circuit in Matlab-simulink

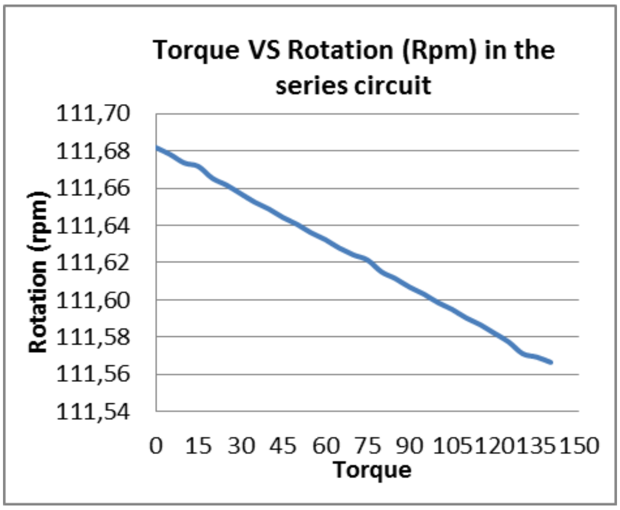

Figure. 4. Graphic of the relation between torque and rpm at the series circuit

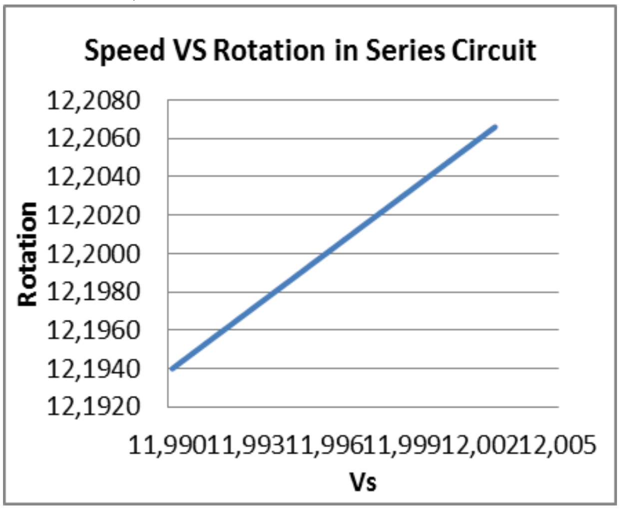

Figure. 5. Graphic of the relationship between Rotatiom and Speed in series circuit

From the figure 3 circuit DC motor series using Matlab-Simulink, there is scope in the form of graphs. The simulation was performed within 5 seconds. There is some data to be inputted, among others, a large voltage on each battery, In this circuit, the voltage generated by the series circuit in a battery of 190V with AH 10260. After a series of simulated results obtained graphs among others: chast current field, the current armature, speed and torque.

After running for 5 seconds on matlab-simulink it will automatically generate a graph. Scope of circuit, taken data is constant and input the data in the table observations, repeat until all the variations do. In this trial insert torque variation of 0-140. However, the variation can simply enter the numbers 0-14 with a difference of 0.5 so that tertlis the torque variation is 0 or 0.5 or 1 or 1.5 or 2 or 2.5, and so on until the 14 variations.

Enter the observational data in the table 1, so make chart from these tabel with variation torque-rotation, Rotation and speed, performance.

Figure 4 shows the relationship rotation (RPM) and torque in a series circuit. Based on the graph, the torque value is directly proportional to the value of rotation (rpm). When torque is 0 then the value of rad / s at 111.68. When the value of maximum torque, it is precisely the value of rad / s was only 111.57 for the full usage of 100%. This means that the torque value is inversely proportional to the value of rotation (rpm).

Figure 5 shows the relationship between rotation (rad / s) and Vs (Knot) in the series circuit. Based on the graph, the value of rotation (rad / s) is proportional to the value of Vs (knots). As at the time of his round 12.2066 rad / s speed indicates the number 12.003 knots and this is the maximum value of the series circuit. Meanwhile, when the current value of the rotation is 12.2 rad / s the value of his service speed was 11.996 knots and it is the middle value of the graph above. As for the minimum value is the current value of the rotation is 12.194 rad / s and the velocity value is 11.990 knots. It is enough to prove that the rotation speed and proportional.

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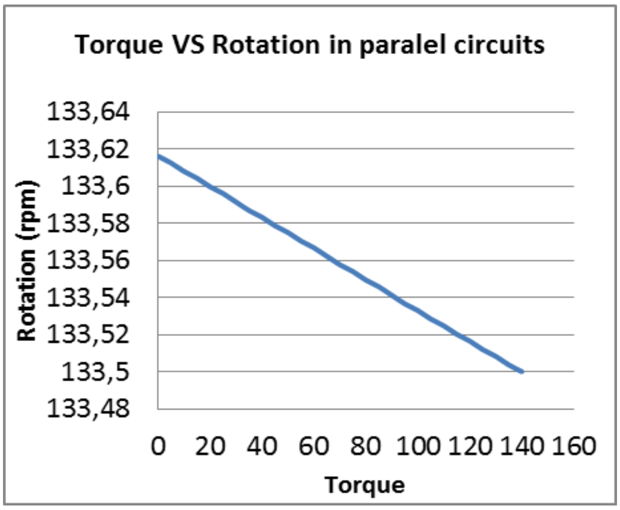

Figure. 6. Graphic of the relationship between torque and rotation in parallel circuit

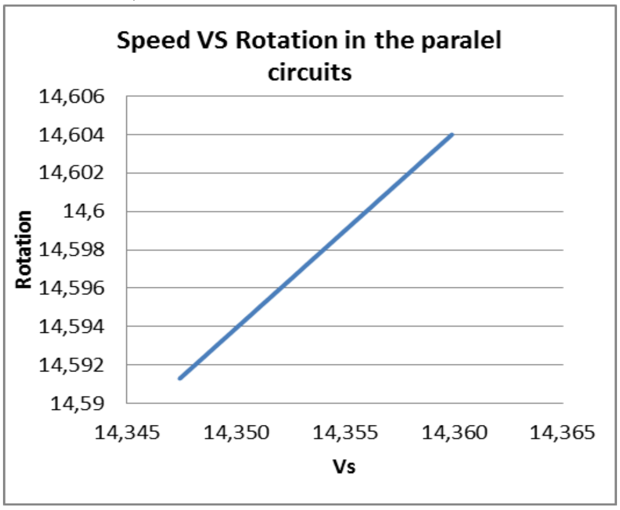

Figure. 7. Relation between Rotatiom and speed

Figure 6 show the graph of the relationship between torque and rotation torque (rpm) in a parallel circuit. Based on the graph, the torque value is inversely proportional to the value of rotation (rpm). When torque is 0 then the value of 133.62 rpm. When torque 50 putarannnya value of 133.56 rpm. When the maximum torque value of 140, it was only 133.5 rpm value for the use of the full 100%. This means that the torque value is inversely proportional to the value of rotation (rpm). When the torque value is small then big and reverse rotation torque value greater then rotation a great value.

Figure 7 show the relationship between rotation (rad / s) and Vs (Knot) in a parallel circuit. Based on the graph, the value of rotation (rad / s) is proportional to the value of Vs (knots). As at the time of his round 14.604 rad / s speed indicates the number 14.360 knots and this is the maximum value of the parallel circuit. Meanwhile, when the current value of rotation 14.5976 rad / s the value of his service speed was 14.354 knots and it is the middle value of the graph above. As for the minimum value is the current value of rotation 14.5916 rad / s and the velocity value is 14.347 knots. It is enough to prove that the rotation speed and proportional.

E. Calculation of eficiency

To calculate the efficiency, it is necessary to use the calculation as follows:

a. Determining the value of the current armature
Ia was on the the motor taken there on the motor or the scope of measurement data on circuit in matlab. Valued of Ia : 38.2477 A

b. Determining the value of the current field
If the motor taken there on the motor or the scope of measurement data on circuit in matlab. If the value: 3.255 A

c. Determining the value of current flowing source (IL)
IL = Ia + If
= 38.2477 + 3.255
= 41.5027 A

d. Determining the value of the input power (Pin)
Pin = Vt x IL
= 190 x 41.5027
= 7885.513 watts

e. Determining the value of Prisoners anchor (Ra)
Armature resistance value is the value of resistance on the motor and this is contained in the machine parameters in the DC block and the value was 0.06727 ohm

f. Determining the value detainee field (Rf)
The resistance field value is the value of resistance on the motor and this is contained in the machine parameters in the DC block and the value was 30.72 ohms

g. Determining the value of loss of copper (WCU)
WCU = (Ia^2 Ra) + (If^2 Rf)
= (38.24772 x 0.06727) + (3.2552 x 30.72)
= 423.8875 watt

h. Determining the value of iron loss and mechanical
W (b + m) = 20% WCU
= 84.777 watts

i. Determining the value of total loss (Wtot)
Wtot = Wcu + W (b + m)
= 423.8875 + 84.777
= 508.6651 watt

j. Determining the value of the output power (Pout)
Pout = Pin - Wtot
= 7885.513-508.6651
= 7376.848 watt

k. Determining the value of efficiency (η)
Eff = Pout / Pin x 100%
= 7376.848 / 7885.513 x 100%
= 93.5493%

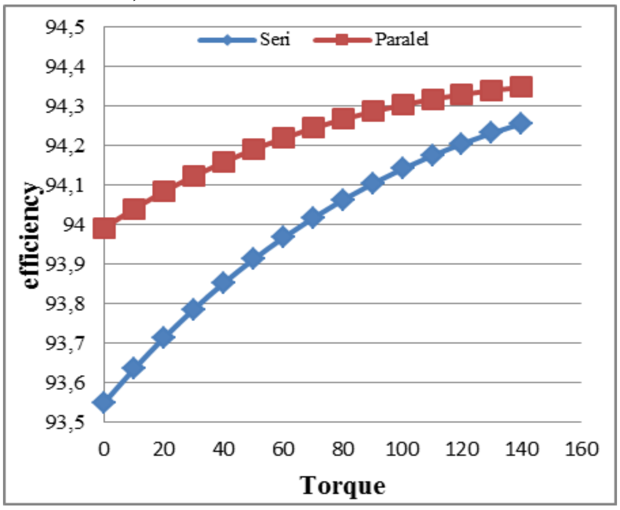

Figure. 8. comparison between eficiency and torque

From Figure 8. In the graph above can be seen that the efficiency of circuit, the relationship is directly proportional to the torque, if the torque higher the value the higher the efficiency. The maximum value on the graph above is if torque is 140 then the efficiency is 94.3% but with a torque value of 0 to a parallel circuit still has a value of an efficiency of 93.99%.

As for the series circuit is if torque is 140 then the efficiency is 94.2% but with a torque value of 0 to a series circuit still has value at 93.5% efficiency. For the price of efficiency in both circuit comparison and the higher parallel circuits.

TABLE 4.
SIMULATION RESULT OF SERIES CIRCUITS WHEN USAGE ON 10%

Q Motor	Torque	rad/s	RPM	RPS	THP	SHP	BHP	Va	Vs (m/s)	Vs (knot)
26,788	0	10,7854	98,6788	1,6446	0	0	0	3,2367	5,4581	10,6051
27,703	10	10,7844	98,6697	1,6445	677,26032	691,08196	813,0376	3,2364	5,4576	10,6041
28,589	20	10,7835	98,6614	1,6444	1354,4076	1382,0486	1625,9395	3,2361	5,4572	10,6033
29,839	30	10,7826	98,6532	1,6442	2031,44184	2072,8998	2438,7057	3,2358	5,4567	10,6024
30,682	40	10,7818	98,6459	1,6441	2708,38811.6	2763,6614	3251,3663	3,2356	5,4563	10,6016
31,659	50	10,7808	98,6367	1,6439	3385,1712	3454,2563	4063,831	3,2353	5,4558	10,6006
32,546	60	10,7799	98,6285	1,6438	4061,86632	4144,7616	4876,1901	3,2350	5,4553	10,5997
33,494	70	10,7790	98,6203	1,6437	4738,4484	4835,1514	5688,4134	3,2347	5,4549	10,5988
34,366	80	10,7781	98,6120	1,6435	5414,91744	5525,426	6500,5011	3,2345	5,4544	10,5979
35,276	90	10,7772	98,6038	1,6434	6091,27344	6215,5851	7312,4531	3,2342	5,4540	10,5971
36,185	100	10,7763	98,5956	1,6433	6767,5164	6905,629	8124,2694	3,2339	5,4535	10,5962
37,095	110	10,7754	98,5873	1,6431	7443,64632	7595,5575	8935,95	3,2337	5,4531	10,5953
38,005	120	10,7745	98,5791	1,6430	8119,6632	8285,3706	9747,4948	3,2334	5,4526	10,5944
39,215	130	10,7736	98,5709	1,6428	8795,56704	8975,0684	10558,904	3,2331	5,4521	10,5935
40,559	140	10,7726	98,5617	1,6427	9471,26992	9664,5611	11370,072	3,2328	5,4516	10,5925

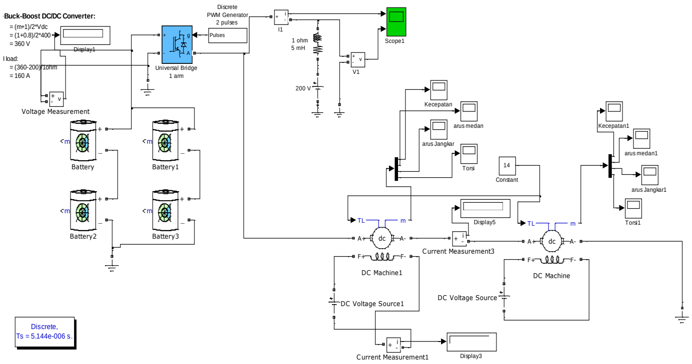

Figure. 9. Series circuit with converter in Matlab-simulink

TABLE 5.
SIMULATION RESULT OF PARALLEL CIRCUITS WHEN USAGE ON 10%

Q Motor	Torque	rad/s	RPM	RPS	THP	SHP	BHP	Va	Vs (m/s)	Vs (knot)
26,788	0	13,788	126,1505	2,1025	0	0	0	4,1377	6,9776	13,5575
27,7033	10	13,7871	126,1423	2,1024	865,8299	883,4999	1039,4116	4,1375	6,9772	13,5567
28,5895	20	13,7862	126,134	2,1022	1731,5467	1766,8844	2078,6875	4,1372	6,9767	13,5558
29,8399	30	13,7853	126,1258	2,1021	2597,1505	2650,1536	3117,8278	4,1369	6,9763	13,5549
30,682	40	13,7844	126,1176	2,1020	3462,6413	3533,3074	4156,8323	4,1367	6,9758	13,5540
31,6595	so	13,7835	126,1093	2,1018	4328,0190	4416,3459	5195,7011	4,1364	6,9754	13,5531
32,5467	60	13,7826	126,1011	2,1017	5193,2837	5299,2691	6234,4342	4,1361	6,9749	13,5522
33,4941	70	13,7817	126,0929	2,1015	6058,4353	6182,0769	7273,0316	4,1358	6,9744	13,5513
34,3663	80	13,7808	126,0846	2,1014	6923,4739	7064,7693	8311,4933	4,1356	6,9740	13,5505
35,2761	90	13,7799	126,0764	2,1013	7788,3995	7947,3464	9349,8193	4,1353	6,9735	13,5496
36,1859	100	13,779	126,0682	2,1011	8653,2120	8829,8082	10388,0096	4,1350	6,9731	13,5487
37,0957	110	13,7781	126,0599	2,1010	9517,9115	9712,1546	11426,0642	4,1348	6,9726	13,5478
38,0055	120	13,7772	126,0517	2,1009	10382,4979	10594,3856	12463,9831	4,1345	6,9722	13,5469
39,2153	130	13,7763	126,0435	2,1007	11246,9713	11476,5013	13501,7663	4,1342	6,9717	13,5460
40,559	140	13,7754	126,0352	2,1006	12111,3317	12358,5017	14539,4138	4,1340	6,9713	13,5452

Based on tabel 4, the input data is carried out, at the time included 10% of the battery. From the calculation of the formula, it can be seen Vs or speed service on the series circuit. Like for example when the inputted torque variation 0 it will be produced BHP was 0 kW while the speed in rad / s is 10.7854 and its speed Vs is 10.6051 knots. As for BHP produced by 11370.072 140 KW while the speed in rad / s is 10.7726 and its speed Vs is 10.5925 knots. The series circuit with converter in Matlab-Simulink are presented on Figure 9.

Based on tabel 5, the input data is carried out, at the time included 10% of the battery. From the calculation of the formula, it can be seen Vs or speed boat service on a parallel circuit. Like for example when the inputted torque variation 0 it will be produced BHP was 0 kW while the speed in rad / s is 13.788 and its speed Vs is 13.5575 knots. As for BHP produced by 14539.4138 140 KW while the speed in rad / s is 13.7754 and its speed Vs is 10.5452 knots. The parallel circuit with converter in Matlab-Simulink are presented on Figure 10.

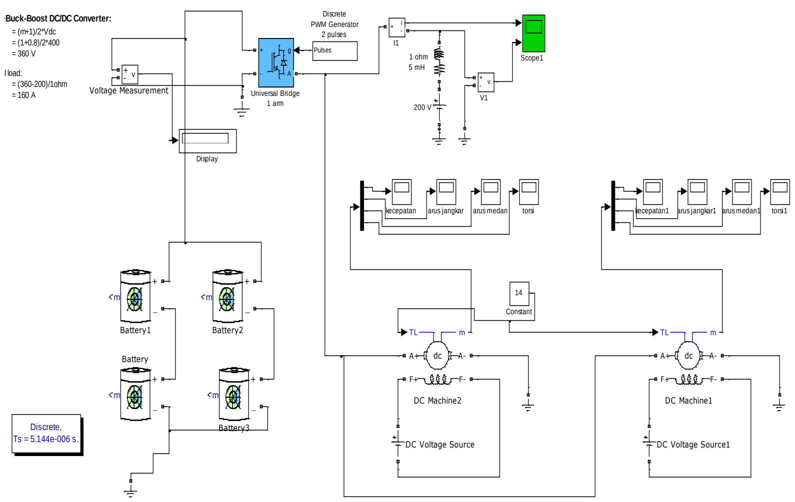

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Figure. 10. Paralel circuit with converter in Matlab-simulink

TABLE 6.
SIMULATION RESULT OF SERIES CIRCUITS WITH CONVERTER

Capacity (%)	Q Motor	Torque	rad/s	Drop voltage	RPM	RPS	THP	SHP	BHP	Va	Vs (m/s)	Vs (knot)
100%	38,8	140	11,3325	222	103,6844	1,7281	9963,534	10166,87	11961,03	3,4008	5,7350	11,1431
90%	37,4	140	10,7892	205,8	98,7136	1,6452	9485,865	9679,454	11387,59	3,2378	5,4600	10,6089
80%	36	140	10,7798	205,6	98,6276	1,6438	9477,6	9671,021	11377,67	3,2350	5,4553	10,5996
70%	37,75	140	10,77	205,4	98,5379	1,6423	9468,984	9662,229	11367,33	3,2320	5,4503	10,5900
60%	33,2	140	10,757	205,1	98,4190	1,6403	9457,554	9650,566	11353,61	3,2281	5,4437	10,5772
50%	39,94	140	10,734	204,8	98,2085	1,6368	9437,333	9629,931	11329,33	3,2212	5,4321	10,5546
40%	40,188	140	10,7094	204,2	97,9835	1,6331	9415,704	9607,862	11303,37	3,2139	5,4197	10,5304
30%	33,2	140	10,664	203,3	97,5681	1,6261	9375,789	9567,131	11255,45	3,2002	5,3967	10,4858
20%	39,005	140	10,5709	201,6	96,7163	1,6119	9293,935	9483,607	11157,19	3,1723	5,3496	10,3942
10%	39,22	140	10,2885	196,2	94,1325	1,5689	9045,649	9230,254	10859,12	3,0875	5,2067	10,1165

According to Table 6, to get data with a speed of 0 (error) then on the number of attempts to input the data included 0.539% on the battery. From the calculation of the formula, it can be seen Vs or speed boat service on the series circuit. Like for example when the inputted torque variation 0 it will be produced BHP was 0 kW while the speed in rad / s is 0.5334 and its speed Vs is 0.5245 knots. As for the variations in torque produced 140 BHP at 548.9459 KW while the speed in rad / s is 0.5201 and its speed Vs is 0.5114 knots. At the time of full torque, the full capacity of its service speed is 11.1 knots. This proves if at the time of full torque condition then speeds between 10-11 knots for the series circuit.

IV. CONCLUSION

Based on the result, the conclusion of this research are following:

1. The service speed of parallel circuit of the motor submerged vehicle is 14 knots and the speed of the condition of the vessel is in a state patrol as usual.
2. The service speed of series circuit of the motor submerged vehicle is 12 knots and the speed of the condition of the vessel is in a state patrol as usual.
3. Motor circuit in parallel with the converter services speed is 11 knots and the speed of the condition of the vessel is in a state patrol as usual.
4. Motor circuit in series with the converter services speed was 21.5 knots and at that speed condition of the vessel is in a state patrol as usual and this speed is the maximum speed.

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