Analysis of Electric Propulsion Performance on Submersible with Motor DC, Supply Power 10260AH at Voltage 115VDC

Indra Ranu Kusuma[1], Sardono Sarwito[2], Ristita Angarini Widya Ayu Irawati[3]

***Abstract*— electric propulsion is the ship system using propulsion motor to replace performance of main engine. The application of diesel engine as propulsion system have some problems and weaknesses such as diesel engine unability to operate when submersible vessel is operating under sea. To overcome that problems in submersible vessel, alternative solution of ship propulsion is required. DC Motor can be used as this alternative solution. Submersible vessel use electric propulsion system with DC Motor because DC Motor has advantages of easy rotation setting and does not cause noise when submersible vessel is diving. This bachelor thesis will study the application of DC Motor as an electric propulsion system on submersible vessel with length 59,57 m in series and parallel circuit by simulation using MATLAB software. The simulation data obtained are rotation and torque of DC Motor. From these simulation, it can be concluded that parallel circuit rotation is greater than series circuit rotation. It caused the greater speed and lower power in parallel circuit.**

Keywords—DC motor, electric propulsion, MATLAB, submersible

I. INTRODUCTION

Electric propulsion is the ship system using propulsion motor to replace performance of main engine. In general, special ship uses DC motor for propulsion propeller and merchant ship generally uses AC motor. DC electric motor can be used as a main propulsion and used on ships with high maneuverability, special ships, ships with a large cargo capacity, and ships using non-reversible prime movers. In general, ships use diesel engine as propulsion for propeller. But using diesel engine as propulsion for propeller have some problems and weaknesses such as diesel engine inability to operate when submersible vessel is operating under sea. To overcome that problems in submersible vessel, alternative solution of ship propulsion is required. DC Motor can be used as this alternative solution. Submersible vessel use electric propulsion system with DC Motor.

Electric propulsion system used in ship have four advantages. They are simplification of the propulsion system, silencing of onboard noise, improved fuel efficiency during travel due to the ability to constantly maintain a rotational speed that offers good fuel efficiency in the motors used for producing propulsive electric power and in the case of ships that consume extremely large amounts of power, a reduction in the financial burden of maintenance and repair including life cycle costs, due to the integration of propulsion motors with power generation motors for use in supporting general internal electrical load. Disadvantages include a higher initial cost when compared to propulsion systems based on internal combustion engines, increased energy conversion loss from fuel to propulsion, and a larger system volume due to the large number of component parts. Electric propulsion systems are often used on ship such as icebreakers or oceanographic research vessels that take advantage of the aforementioned operational benefits, or large passenger cruise ships and others that emphasize cost and silent operation [1].

II. METHOD

The first step is calculating resistance on submersible vessel. The submersible has length of 59.57 m. To calculate the resistance submersible use the formula [2]:

$$R_{BH} = 0.5\rho AV^2C_t \quad (1)$$

$$R_{APP} = 0.5\rho AV^2C_t \quad (2)$$

$$R_T = R_{BH} + R_{APP} \quad (3)$$

Where, R_t is total resistance, R_{bh} is bare hull resistance, R_{app} is resistance of the appendages, A is reference area of the submersible, V is velocity of the submersible, and C_t is non dimensional drag coefficient. So, total resistance on the submersible is 128.594 kN.

After total resistance known, then total required power can be calculated. To calculate the torque needed on submersible use the formula:

$$EHP = Rt \times V \quad (4)$$

$$THP = ((1 - w)/(1 - t)) \times EHP \quad (5)$$

$$Q = PHP/2\pi n \quad (6)$$

Where, EHP (effective horse power) is the product total resistance and the submersible speed, Rt is total resistance, V is speed of the submersible, THP (thrust horse power) is the product of the thrust delivered by power from the propeller and the submersible speed, t is thrust deduction, w is wake fraction, Q is torque, PHP (propulsive horse power) is the power delivered to the ppropulsor and n is rotation. So, the torque required is 129 Nm. This torque will be used as a load for the DC motor when the simulation process is carried out.

Figure 1 and 2 is a circuit in a DC motor that will be simulated. Pictures of the circuit is used to create a model reference circuit in MATLAB SIMULINK software then the circuit will be run.

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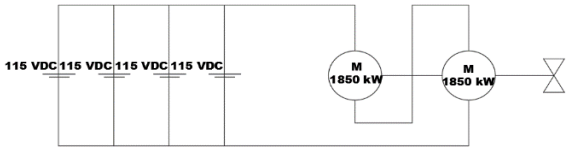

Figure. 1. DC motor series circuit to be simulated

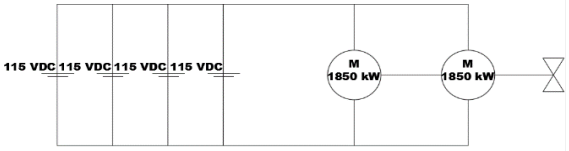

Figure. 2. DC motor parallel circuit to be simulated

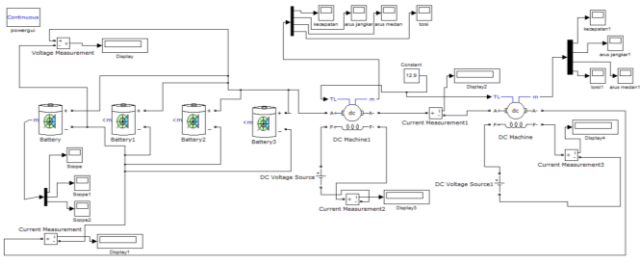

Figure. 3. DC motor series circuit in Simulink

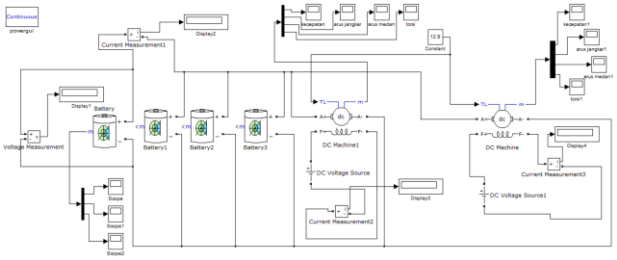

Figure. 4. DC motor parallel circuit in Simulink

Figures 3 and 4 are a series and parallel circuit of DC motor using SIMULINK. The process simulation performed for 10 seconds. Figures 5 and 6 are series and parallel of DC motor with DC-DC converter using SIMULINK. The process simulation performed for 1 seconds. The voltage on the battery is 115 V with a capacity of 10260 AH. Then the input torque is the torque required by the ship. Torque required the ship is 129 Nm. Series and parallel circuit in MATLAB software will be run to get the data rotation and torque on the motor with torque variation charged.

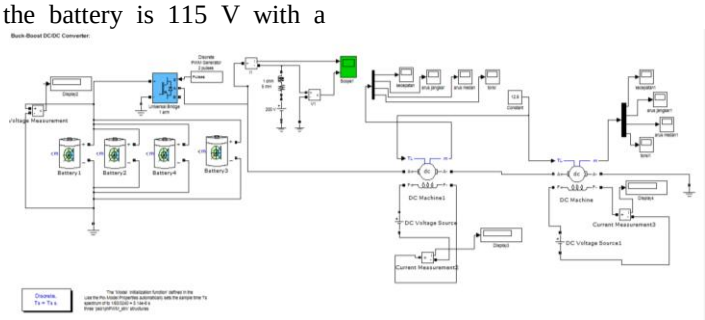

Figure. 5. DC motor series circuit with DC-DC converter in Simulink

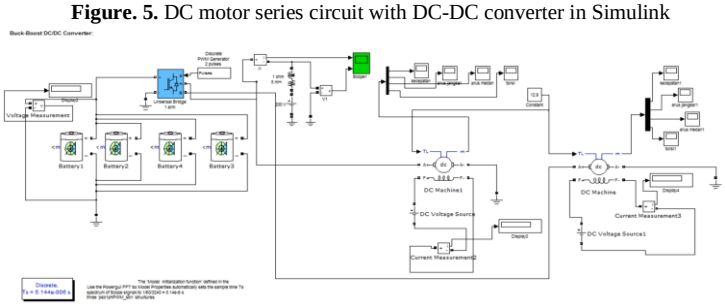

Figure. 6. DC motor parallel circuit with DC-DC converter in Simulink

III. RESULT AND DISCUSSION

The following data obtained from the simulation results:

TABLE 1.
DATA ROTATION AND TORQUE ON SERIES CIRCUIT OF SIMULATION

Rotation (rad/s)	Rotation (RPM)	Torque of ship	Torque of motor
2,6448	25,25598	129	39,6
2,6448	25,25598	124	39,1
2,6449	25,25693	119	38,3
2,6449	25,25693	114	37,8
2,6450	25,25789	109	37,5
2,6450	25,25789	104	37,1
2,6451	25,25884	99	36,6
2,6451	25,25884	94	36
2,6452	25,25980	89	35,4
2,6452	25,25980	84	34,9
2,6453	25,26075	79	34,5
2,6454	25,26171	74	34
2,6454	25,26171	69	33,4
2,6455	25,26266	64	32,8
2,6455	25,26266	59	32,3
2,6456	25,26362	54	32,1
2,6456	25,26362	49	31,4
2,6457	25,26457	44	31
2,6457	25,26457	39	30,4
2,6458	25,26553	34	30
2,6458	25,26553	29	29,5
2,6459	25,26648	24	29
2,6459	25,26648	19	28,5
2,6460	25,26744	14	27,9
2,6460	25,26744	9	27,4
2,6461	25,26839	4	27
2,6461	25,26839	0	26,6

TABLE 2.
DATA ROTATION AND TORQUE ON PARALLEL CIRCUIT OF SIMULATION

Rotation (rad/s)	Rotation (RPM)	Torque of ship	Torque of motor
5,2937	50,55111	129	39,4
5,2937	50,55111	124	38,9
5,2938	50,55207	119	38,5
5,2938	50,55207	114	37,9
5,2939	50,55302	109	37,4
5,2939	50,55302	104	36,9
5,2940	50,55398	99	36,4
5,2940	50,55398	94	35,9
5,2941	50,55493	89	35,4
5,2941	50,55493	84	35,2
5,2942	50,55589	79	34,3
5,2942	50,55589	74	34,1
5,2943	50,55684	69	33,6
5,2943	50,55684	64	33,2
5,2944	50,55780	59	32,4
5,2944	50,55780	54	32,1
5,2945	50,55875	49	31,4
5,2946	50,55971	44	30,9
5,2946	50,55971	39	30,7
5,2947	50,56066	34	30,2
5,2947	50,56066	29	29,6
5,2948	50,56162	24	28,8
5,2948	50,56162	19	28,4
5,2949	50,56257	14	28,2
5,2949	50,56257	9	27,6
5,2950	50,56353	4	26,9

5,2950	50,56353	0	26,7

TABLE 3.
DATA ROTATION AND TORQUE ON SERIES CIRCUIT WITH DC-DC CONVERTER OF SIMULATION

Voltage	Rotation (rad/s)	Rotation (RPM)	Torque of ship	Torque of motor
134,4	2,4062	22,97752	10	64,96
134,4	2,4061	22,97656	20	65,85
134,4	2,4060	22,97561	30	66,96
134,4	2,4059	22,97465	40	67,83
134,4	2,4058	22,97370	50	68,96
134,4	2,4057	22,97274	60	69,85
134,4	2,4056	22,97179	70	70,96
134,4	2,4055	22,97083	80	71,82
134,4	2,4054	22,96988	90	72,96
134,4	2,4053	22,96892	100	73,85
134,4	2,4052	22,96797	110	74,96
134,4	2,4051	22,96701	120	75,85
134,4	2,4050	22,96606	129	76,96

TABLE 4.
DATA ROTATION AND TORQUE ON CIRCUIT WITH DC-DC CONVERTER OF SIMULATION

Voltage	Rotation (rad/s)	Rotation (RPM)	Torque of ship	Torque of motor
134,4	4,8152	45,98177	10	102,46
134,4	4,8151	45,98082	20	103,4
134,4	4,8150	45,97986	30	104,47
134,4	4,8149	45,97891	40	105,47
134,4	4,8148	45,97795	50	106,4
134,4	4,8147	45,97700	60	107,47
134,4	4,8146	45,97604	70	108,46
134,4	4,8145	45,97509	80	109,4
134,4	4,8144	45,97413	90	110,47
134,4	4,8143	45,97318	100	111,47
134,4	4,8142	45,97222	110	112,43
134,4	4,8141	45,97127	120	113,47
134,4	4,8140	45,97031	129	114,47

To calculate speed of ship use formula:

$$Vs = Va/((1-w)) \quad (4)$$

The results of the calculation as follows:

TABLE 5.
THE RESULTS OF CALCULATION OF POWER AND SPEED IN SERIES CIRCUIT

Rotation		Q (Nm)	THP	SHP	BHP	Va	Vs	Vs	Vs	Shaft Torque
RPM	RPS				(kW)		(m/s)	(Knot)	(Knot)	
25.26839	0.42114	0	0.00000	0.00000	0.00000	0.89096	1.39213	2.70608	3	0
25.26839	0.42114	4	10.57903	10.36745	12.19700	0.89096	1.39213	2.70608	3	3.92
25.26744	0.42112	9	23.80193	23.32589	27.44222	0.89093	1.39208	2.70598	3	8.82
25.26744	0.42112	14	37.02522	36.28472	42.68790	0.89093	1.39208	2.70598	3	13.72
25.26648	0.42111	19	50.24661	49.24168	57.93139	0.89090	1.39203	2.70587	3	18.62
25.26648	0.42111	24	63.46941	62.20002	73.17649	0.89090	1.39203	2.70587	3	23.52
25.26553	0.42109	29	76.68930	75.15552	88.41825	0.89086	1.39197	2.70577	3	28.42
25.26553	0.42109	34	89.91160	88.11336	103.66278	0.89086	1.39197	2.70577	3	33.32
25.26457	0.42108	39	103.12999	101.06739	118.90281	0.89083	1.39192	2.70567	3	38.22
25.26457	0.42108	44	116.35178	114.02475	134.14676	0.89083	1.39192	2.70567	3	43.12
25.26362	0.42106	49	129.56868	126.97731	149.38507	0.89080	1.39187	2.70557	3	48.02
25.26362	0.42106	54	142.78998	139.93418	164.62844	0.89080	1.39187	2.70557	3	52.92
25.26266	0.42104	59	156.00537	152.88526	179.86502	0.89076	1.39181	2.70547	3	57.82
25.26266	0.42104	64	169.22617	165.84164	195.10782	0.89076	1.39181	2.70547	3	62.72
25.26171	0.42103	69	182.44006	178.79126	210.34266	0.89073	1.39176	2.70536	3	67.62
25.26171	0.42103	74	195.66036	191.74715	225.58488	0.89073	1.39176	2.70536	3	72.52
25.26075	0.42101	79	208.87276	204.69530	240.81800	0.89069	1.39171	2.70526	3	77.42
25.25980	0.42100	84	222.08416	217.64247	256.04997	0.89066	1.39166	2.70516	3	82.32
25.25980	0.42100	89	235.30345	230.59738	271.29104	0.89066	1.39166	2.70516	3	87.22
25.25884	0.42098	94	248.51335	243.54308	286.52127	0.89063	1.39160	2.70506	3	92.12
25.25884	0.42098	99	261.73215	256.49750	301.76177	0.89063	1.39160	2.70506	3	97.02
25.25789	0.42096	104	274.94055	269.44174	316.99028	0.89059	1.39155	2.70495	3	101.92
25.25789	0.42096	109	288.15884	282.39567	332.23019	0.89059	1.39155	2.70495	3	106.82
25.25693	0.42095	114	301.36574	295.33843	347.45697	0.89056	1.39150	2.70485	3	111.72
25.25693	0.42095	119	314.58354	308.29187	362.69632	0.89056	1.39150	2.70485	3	116.62
25.25598	0.42093	124	327.78894	321.23316	377.92137	0.89053	1.39145	2.70475	3	121.52
25.25598	0.42093	129	341.00624	334.18611	393.16013	0.89053	1.39145	2.70475	3	0

TABLE 6.
THE RESULTS OF CALCULATION OF POWER AND SPEED IN PARALLEL CIRCUIT

Rotation		Q (Nm)	THP	SHP	BHP	Va	Vs	Vs	Vs	Shaft Torque
RPM	RPS				(kW)		(m/s)	(Knot)	(Knot)	
50.56353	0.84273	0	0.00000	0.00000	0.00000	1.78287	2.78573	5.41502	5	0
50.56353	0.84273	4	21.16926	20.74588	24.40691	1.78287	2.78573	5.41502	5	3.92
50.56257	0.84271	9	47.62994	46.67734	54.91452	1.78284	2.78568	5.41492	5	8.82
50.56257	0.84271	14	74.09102	72.60920	85.42259	1.78284	2.78568	5.41492	5	13.72
50.56162	0.84269	19	100.55020	98.53920	115.92847	1.78280	2.78563	5.41482	5	18.62
50.56162	0.84269	24	127.01078	124.47056	146.43596	1.78280	2.78563	5.41482	5	23.52
50.56066	0.84268	29	153.46846	150.39909	176.94011	1.78277	2.78558	5.41471	5	28.42
50.56066	0.84268	34	179.92854	176.32997	207.44702	1.78277	2.78558	5.41471	5	33.32
50.55971	0.84266	39	206.38472	202.25702	237.94944	1.78274	2.78552	5.41461	5	38.22
50.55971	0.84266	44	232.84430	228.18741	268.45578	1.78274	2.78552	5.41461	5	43.12
50.55875	0.84265	49	259.29898	254.11300	298.95647	1.78270	2.78547	5.41451	5	48.02
50.55780	0.84263	54	285.75266	280.03761	329.45601	1.78267	2.78542	5.41441	5	52.92
50.55780	0.84263	59	312.21124	305.96702	359.96120	1.78267	2.78542	5.41441	5	57.82
50.55684	0.84261	64	338.66343	331.89016	390.45901	1.78263	2.78537	5.41431	5	62.72
50.55684	0.84261	69	365.12151	357.81908	420.96362	1.78263	2.78537	5.41431	5	67.62
50.55589	0.84260	74	391.57219	383.74075	451.45970	1.78260	2.78531	5.41420	5	72.52
50.55589	0.84260	79	418.02977	409.66917	481.96373	1.78260	2.78531	5.41420	5	77.42
50.55493	0.84258	84	444.47895	435.58938	512.45809	1.78257	2.78526	5.41410	5	82.32
50.55493	0.84258	89	470.93603	461.51731	542.96155	1.78257	2.78526	5.41410	5	87.22
50.55398	0.84257	94	497.38372	487.43605	573.45417	1.78253	2.78521	5.41400	5	92.12
50.55398	0.84257	99	523.84030	513.36350	603.95705	1.78253	2.78521	5.41400	5	97.02
50.55302	0.84255	104	550.28649	539.28076	634.44795	1.78250	2.78516	5.41390	5	101.92
50.55302	0.84255	109	576.74257	565.20772	664.95026	1.78250	2.78516	5.41390	5	106.82
50.55207	0.84253	114	603.18726	591.12351	695.43942	1.78247	2.78510	5.41379	5	111.72
50.55207	0.84253	119	629.64284	617.04998	725.94115	1.78247	2.78510	5.41379	5	116.62
50.55111	0.84252	124	656.08602	642.96430	756.42859	1.78243	2.78505	5.41369	5	121.52
50.55111	0.84252	129	682.54111	668.89028	786.92975	1.78243	2.78505	5.41369	5	126.42

TABLE 7.
THE RESULTS OF CALCULATION OF POWER AND SPEED IN SERIES CIRCUIT WITH DC-DC CONVERTER

Rotation		Q (Nm)	THP	SHP	BHP	Va	Vs	Vs	Vs	Shaft Torque
RPM	RPS				(kW)		(m/s)	(Knot)	(Knot)	
22.97752	0.38296	10	24.04980	23.56881	27.72801	0.81019	1.26592	2.46074	2	9.8
22.97656	0.38294	20	48.09760	47.13565	55.45371	0.81015	1.26586	2.46064	2	19.6
22.97561	0.38293	30	72.14341	70.70054	83.17711	0.81012	1.26581	2.46054	2	29.4
22.97465	0.38291	40	96.18721	94.26347	110.89820	0.81009	1.26576	2.46043	2	39.2
22.97370	0.38289	50	120.22902	117.82444	138.61699	0.81005	1.26571	2.46033	2	49
22.97274	0.38288	60	144.26882	141.38345	166.33347	0.81002	1.26565	2.46023	2	58.8
22.97179	0.38286	70	168.30663	164.94050	194.04765	0.80999	1.26560	2.46013	2	68.6
22.97083	0.38285	80	192.34244	188.49559	221.75952	0.80995	1.26555	2.46003	2	78.4
22.96988	0.38283	90	216.37625	212.04873	249.46909	0.80992	1.26550	2.45992	2	88.2
22.96892	0.38282	100	240.40806	235.59990	277.17635	0.80988	1.26544	2.45982	2	98
22.96797	0.38280	110	264.43787	259.14912	304.88131	0.80985	1.26539	2.45972	2	107.8
22.96701	0.38278	120	288.46569	282.69637	332.58397	0.80982	1.26534	2.45962	2	117.6
22.96606	0.38277	129	310.08772	303.88596	357.51290	0.80978	1.26529	2.45951	2	126.42

TABLE 8.
THE RESULTS OF CALCULATION OF POWER AND SPEED IN PARALLEL CIRCUIT WITH DC-DC CONVERTER

Rotation		Q (Nm)	THP	SHP	BHP	Va	Vs	Vs	Vs	Shaft Torque
RPM	RPS				(kW)		(m/s)	(Knot)	(Knot)	
45.98177	0.76636	10	48.12759	47.16504	55.48828	1.62132	2.53331	4.92435	5	9.8
45.98082	0.76635	20	96.25318	94.32812	110.97425	1.62128	2.53326	4.92424	5	19.6
45.97986	0.76633	30	144.37677	141.48923	166.45792	1.62125	2.53320	4.92414	5	29.4
45.97891	0.76632	40	192.49836	188.64840	221.93929	1.62122	2.53315	4.92404	5	39.2
45.97795	0.76630	50	240.61796	235.80560	277.41835	1.62118	2.53310	4.92394	5	49
45.97700	0.76628	60	288.73555	282.96084	332.89510	1.62115	2.53305	4.92383	5	58.8
45.97604	0.76627	70	336.85114	330.11412	388.36955	1.62112	2.53299	4.92373	5	68.6
45.97509	0.76625	80	384.96474	377.26545	443.84170	1.62108	2.53294	4.92363	5	78.4
45.97413	0.76624	90	433.07634	424.41481	499.31154	1.62105	2.53289	4.92353	5	88.2
45.97318	0.76622	100	481.18594	471.56222	554.77908	1.62101	2.53283	4.92343	5	98
45.97222	0.76620	110	529.29354	518.70766	610.24431	1.62098	2.53278	4.92332	5	107.8
45.97127	0.76619	120	577.39914	565.85115	665.70724	1.62095	2.53273	4.92322	5	117.6
45.97031	0.76617	129	620.69118	608.27735	715.62042	1.62091	2.53268	4.92312	5	126.42

Silent mode operation is an operation used by submersibles when they want to infiltrate enemy territory or to hide from the enemy. Silent operation mode has a speed of 1 knot up to 6 knots. So the series circuit has been simulated to have a speed of 2 until 3 knots, the speed is usually used to hide from enemies. Because with that speed, vibrations produced is small, therefore it is easier to be undetected by the enemy. Parallel circuit has a speed of 5 knots that are usually used to infiltrate enemy territory due to speed of 5 knots that usually can not be detected by enemy. Therefore, the opponent can get into opponent's area and opponent can use it to attack enemy territory.

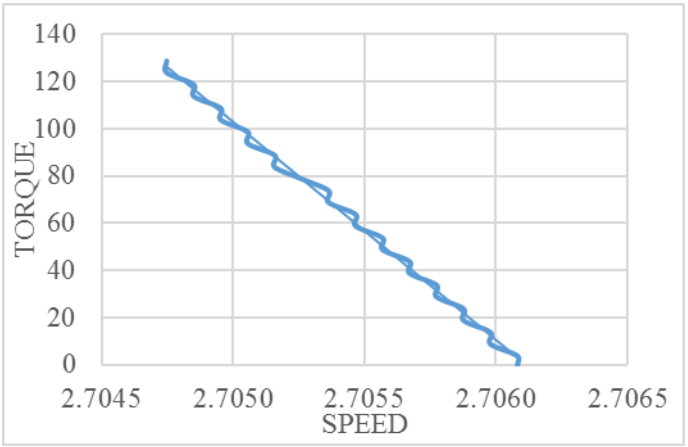

Figure. 7. Graph of speed versus torque in series circuit

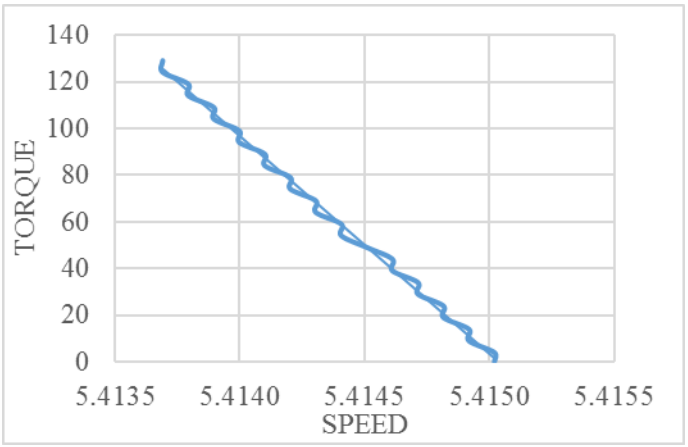

Figure. 8. Graph of speed versus torque in parallel circuit

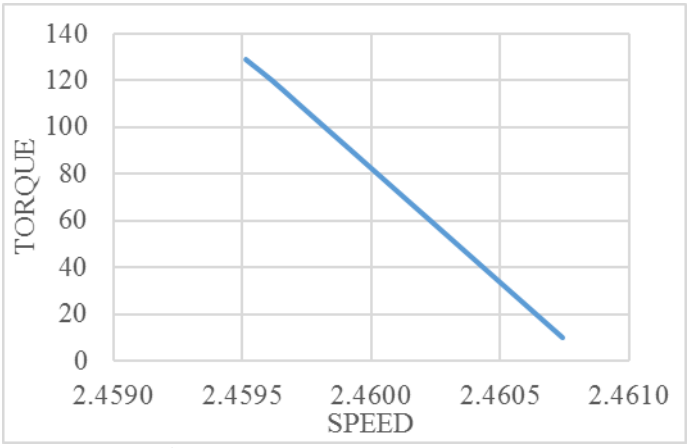

Figure. 9. Graph of speed versus torque in series circuit with DC-DC converter

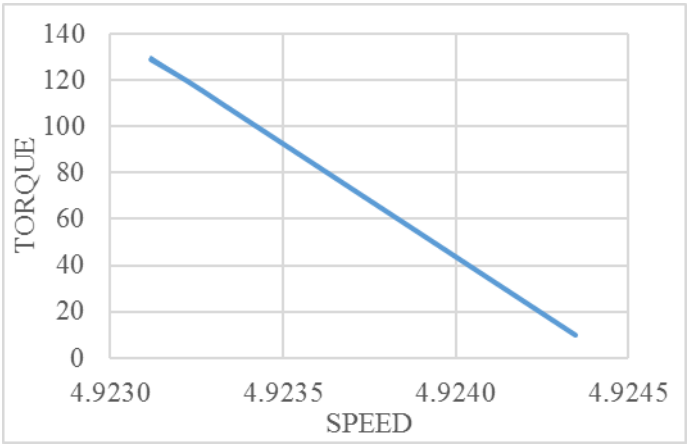

Figure. 10. Graph of speed versus torque in parallel circuit with DC-DC converter

Figure 7, 8, 9 and 10 are the graph showing the relationship between the speed of the torque in series and parallel circuits when the battery is full. Based on the graph, the torque value is inversely proportional to the value of speed. In series circuit, when the speed of the vessel reached its low point of 2.70475 knots then the value of torque produced is the highest of 129 Nm. Meanwhile, when the maximum speed is 2.70608 knots then the value of torque produced is the lowest 0 Nm. While parallel circuit, when the speed of the ship reached its low point of 5.41369 knots then the value of torque produced is the highest of 129 Nm. Meanwhile, when the maximum speed is 5.41502 knots then the value of torque produced is the lowest 0 Nm. In series circuit with DC-DC converter, when the speed of the vessel reached its low point of 2.45951 knots then the value of torque produced is the highest of 129 Nm. Meanwhile, when the maximum speed is 2.46074 knots then the value of torque produced is the lowest 10 Nm. While parallel circuit with DC-DC conveter, when the speed of the ship reached its low point of 4.92312 knots then the value of torque produced is the highest of 129 Nm. Meanwhile, when the maximum speed is 4.92435 knots then the value of torque produced is the lowest 10 Nm. Thus, the torque is directly proportional to Ia.

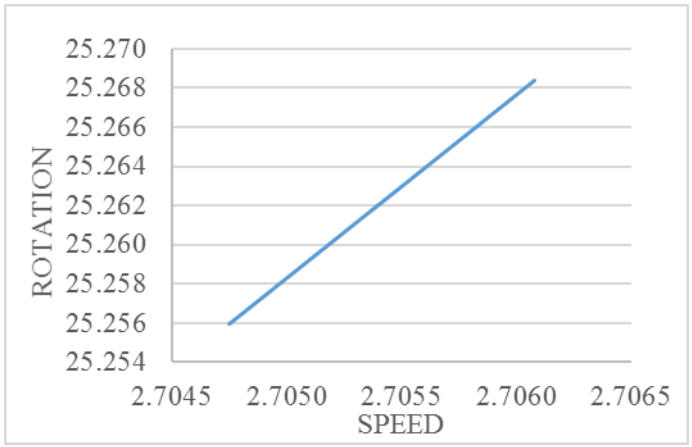

Figure. 11. Graph of speed versus rotation in series circuit

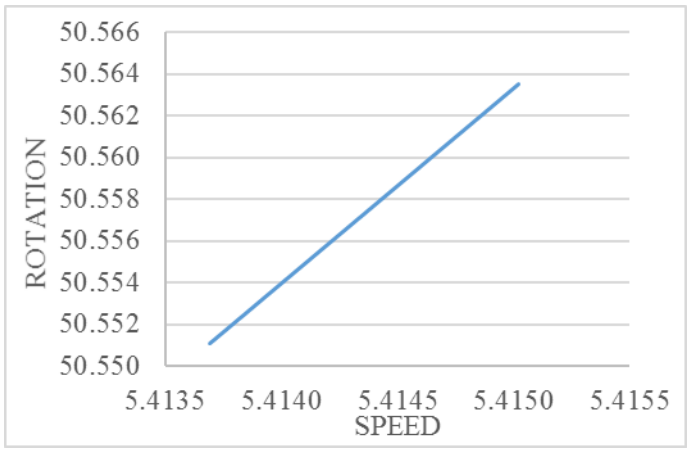

Figure. 12. Graph of speed versus rotation in parallel circuit

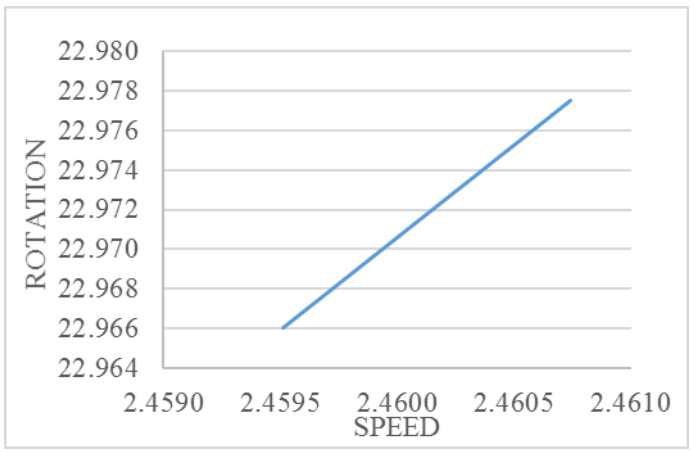

Figure. 13. Graph of speed versus rotation in series circuit with DC-DC converter

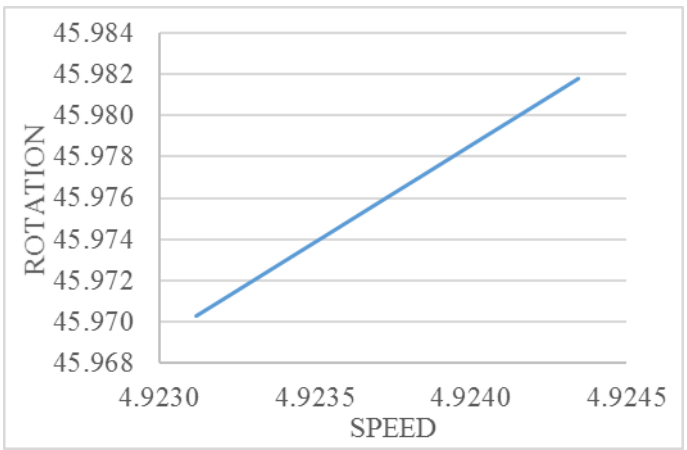

Figure. 14. Graph of speed versus rotation in parallel circuit with DC-DC converter

Figure 11, 12, 13 and 14 are graph showing the relationship between the speed of the rotation in the series and parallel circuits when the battery is full. In a series circuit, when the speed 2.70475 knots, the rotation worth 25.25598 rpm and when the speed 2.70608 knots, the rotation worth 25.26839 rpm. In a parallel circuit, when the speed 5.41502 knots, the rotation worth 50.56353 rpm and when the speed 5.41369 knots, the rotation worth 50.55111 rpm. In a series circuit with DC-DC converter, when the speed 2.45951 knots, the rotation worth 25.96606 rpm and when the speed 2.46074 knots, the rotation 22.97752 rpm. In a parallel circuit with DC-DC converter, when the speed 4.92312 knots, the rotation worth 45.97031 rpm and when the speed 4.92435 knots, the rotation worth 45.98177 rpm. When a ship's speed is maximum speed, the rotation is maximum too. Conversely, if the speed is minimum, the rotation generated is also minimum. Thus, the relationship between speed and the rotation is directly proportional.

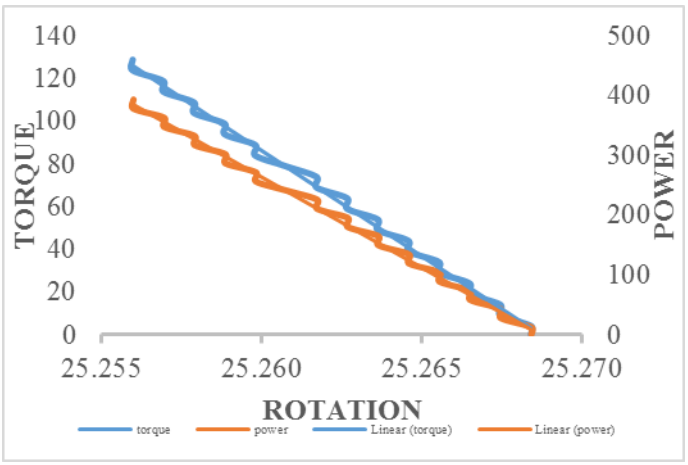

Figure. 15. Graph of rotation versus torque and power in series circuit

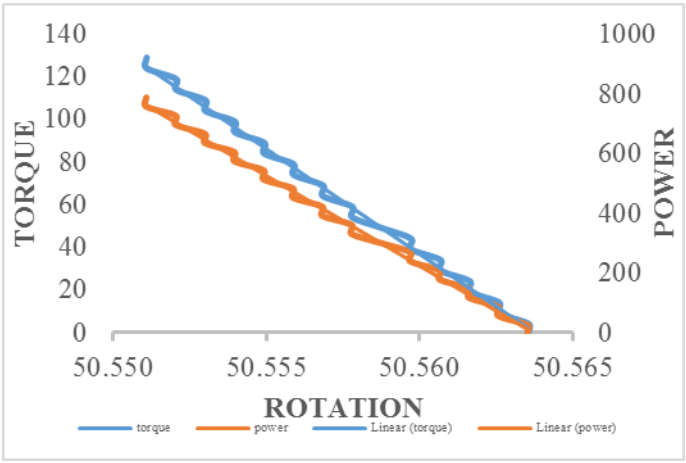

Figure. 16. Graph of rotation versus torque and power in parallel circuit

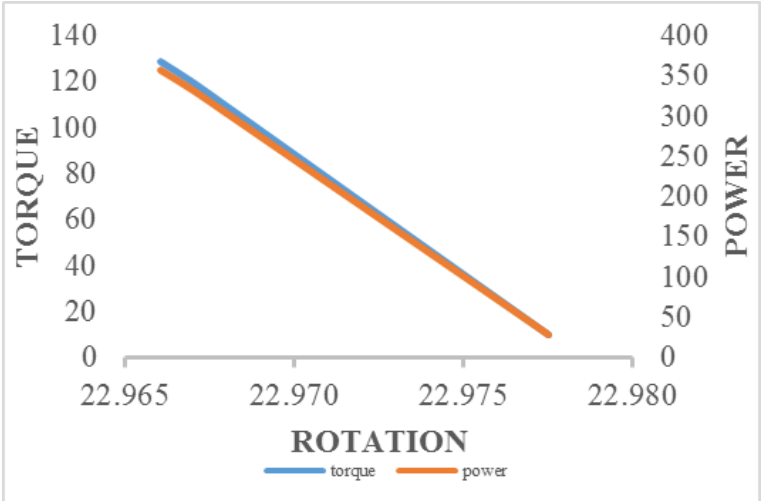

Figure. 17. Graph of rotation versus torque and power in series circuit with DC-DC converter

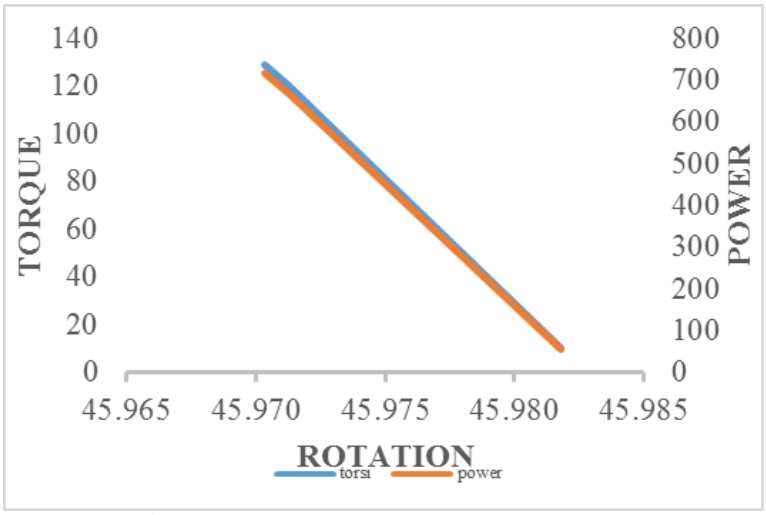

Figure. 18. Graph of rotation versus torque and power in parallel circuit with DC-DC converter

Figure 15, 16, 17 and 18 shows graph of rotation versus torque and power at the series and parallel circuits when the battery is full. In series circuit, when value of torque is 129 Nm, the rotation is 25.25598 rpm and power is 393.16013 kW. In parallel circuit, when value of torque is 129 Nm, the rotation is 50.55111 rpm and power is 786.92975 kW. In series circuit with DC-DC converter, when value of torque is 129 Nm, the rotation is 22.96606 rpm and power is 357.51290 kW. In parallel circuit with DC-DC converter, when value of torque is 129 Nm, the rotation is 45.97031 rpm and power is 715.62042 kW. So, rotation is inversely proportional to the torque and the highest value of rotation require the smallest power.

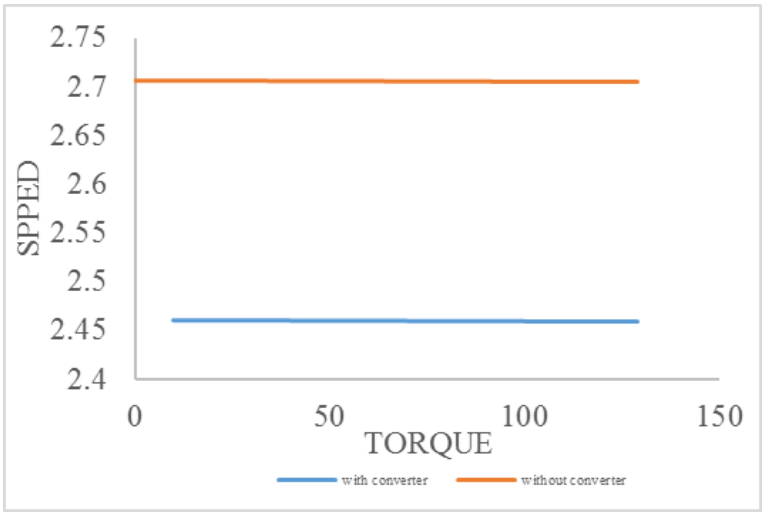

Figure. 19. Graph of torque versus speed in series circuit with and without DC-DC converter

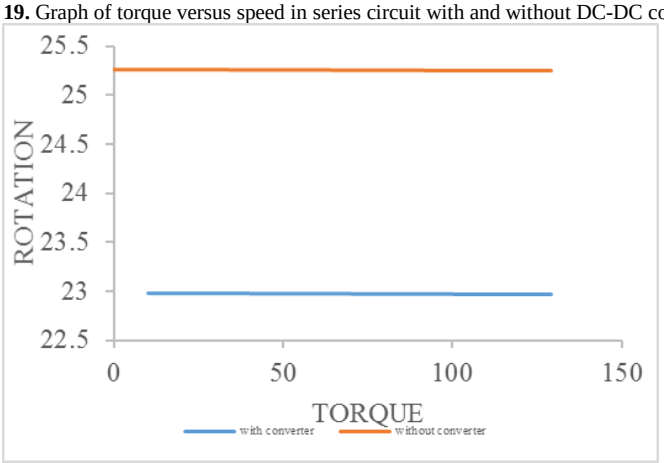

Figure. 20. Graph of torque versus speed in series circuit with and without DC-DC converter

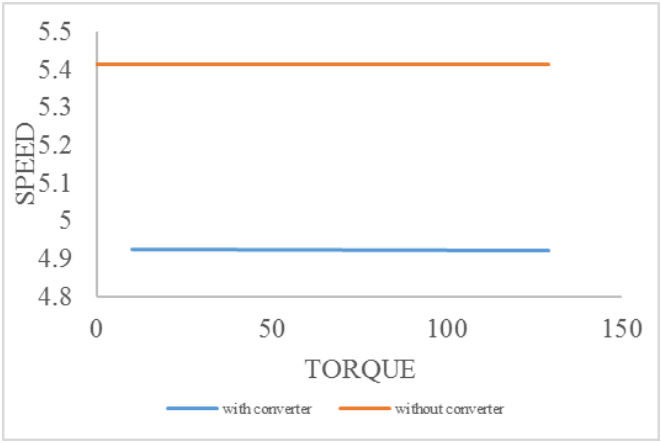

Figure. 21. Graph of torque versus speed in parallel circuit with and without DC-DC converter

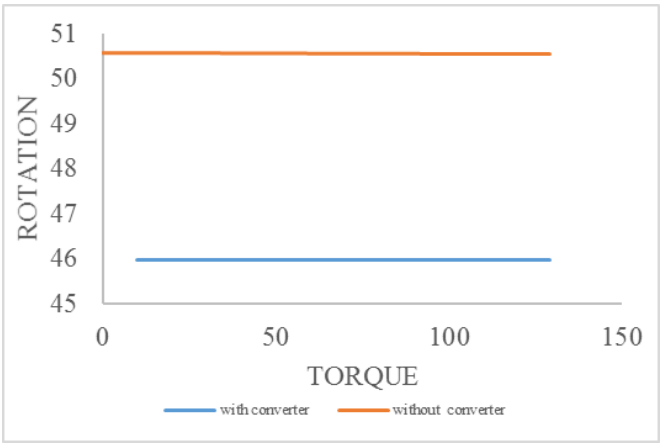

Figure. 22. Graph of torque versus speed in parallel circuit with and without DC-DC converter

Figure 19, 20, 21 and 22 show different speed and torque with and without DC-DC converter in series and parallel circuit when battery is full. Series circuit without DC-DC converter has speed 2,46 knot and rotation 23 rpm. Series circuit with DC-DC converter has speed 2.7 knot and rotation 25.26 rpm. Parallel circuit without DC-DC converter has speed 5.41 knot and rotation 50.55 rpm. Parallel circuit with DC-DC converter has speed 4.92 knot and rotation 45.97 rpm. Circuits with DC-DC converter have smaller speed and rotation than circuits without DC-DC converter.

IV. CONCLUSION

From these process simulation and analysis graphs can be concluded that if the speed increases, the torque generated will decrease. So the relationship between the torque is inversely proportional to the speed.

When a ship's speed is maximum speed, the rotation is maximum too. Conversely, if the speed is minimum, the rotation generated is also minimum. Thus, the relationship between speed and the rotation is directly proportional.

The greater value of the torque need smaller the rotation produced by the motor and more power is needed.

Circuits with DC-DC converter have smaller speed and rotation than circuits without DC-DC converter.

The series circuit simulated has a speed of 2 until 3 knots and is usually used to hide from opponent. While the parallel circuit has a speed of 5 until 5.4 knots and is usually used to infiltrate opponent's area.

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[2] Eugene Allmendinger, "Submersible vehicle systems design", Publish: The Society of Naval Architects and Marine Engineers, 1990, pp.252-258.