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A 3 FT GURINDAM UNMANNED SURFACE VEHICLE (USV) STABILITY HULLFORM PERFORMANCE

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Abstract

3 ft Gurindam Unmanned Surface Vehicle (USV) showed unmaximal performance when it tested on the water. Uncalm movement, unmaximal speed indicated that something need to be checked and make sure to the USV so that it can maximize the performance. The USV is owned by Politeknik Negeri Batam, it's 3 feet long, with single hull type, fuel engine motor and almost 8kg weight. This research aims is to get the stability analytical data so that the researche can collected some data which is will used to maximize the USV performance. From the research it can concluded that the USV has a maximal GZ 9,56cm at 48.2 deg in mimimal weight and maximal GZ 8.88cm at 48.2 deg at the maximall weight of the ship. From this result, it can concluded that the more weight added on the fuel tank (front position) the more unstable condition of the ship. Or, it's need a fixed ballast on the AP area to get the more stability on the USV. Hopefully this reasearh followed by the owner and tested so that the performace of the ship will be maximal.

Keyword: Stability, USV Gurindam, Hull Performance

1.0 INTRODUCTION

3ft USV fuel engine is one of USV designed and made to answer the USV development[1]. This USV made by the student and supervise by lectures which also use on USV competition. When the USV perform, there are some lack of action which is result failed on the performance. Some research conducted and prepared to solve the problem and this research in one the continues development of the USV.

USV itself usually develop by army to do some spying, surveying or defend activity[2][3]. Others use USV to completed some job which is need special purposed without any human involved[4]. From the research it shows that the safety are the most reason to use USV to replace human position during the special activity. Some USV also completed with auto destruction so that if anything happened related with the USV, the data still safe and the USV only become a trash.

Initiation research conduct by the researcher before are related with hull but on catamaran type of hull[5]. This research aims to analyze the hullform performance of the 3ft USV Politeknik Negeri Batam. The goals are to find the condition of ship stability at the difference situation and condition. Also to know what kind of condition are hazardous to the condition of the ship.

2.0 METHODE

Object on this research is a fuel engine USV with transmitter and receiver movement data transferred and human controlled. Made from plywood laminated with fiberglass composite material. The step for this research are redraw the body of the ship using 3D design software and do some analytical process to find the numerical result of the hullform performance. The used of software are aims to minimize the tools but to maximize the result as other research related with the hullform performance analytical [6][7][8][3]. This research will use Delftship software and other hullform analytical software, and than proceed with spreadsheet application to compare the result of software calculation

3.0 RESULT AND DISCUSSION

From an article [9] there are some overview for the development of USV which is researcher resume here:

- Autonomous Surface Craft: prototypes and basic research issues (1996), [10] Basic navigation, guidance and control of an Unmanned Surface Vehicle (2008) [9]
- SCOUT —A Low Cost Autonomous Surface Platform for Research in Cooperative Autonomy (2005) [11]
- U.S. Navy Employment Options For Unmanned Surface Vehicles (Usvs) (2005) [12]

- Vehicle and Mission Control of the DELFIM Autonomous Surface Craft (2006) [13]
- Roaz Autonomous Surface Vehicle Design And Implementation (2006) [14]
- Modelling And Control Of An Unmanned Surface Vehicle For Environmental Monitoring (2008) (2006) [15][16]
- Perencanaan Unmanned Surface Vehicle (Usv) Ukuran 3 Meter Tipe Serbu Cepat (2012) [17]
- Design of a Twin Hull Based USV with Enhanced Maneuverability (2013)[18]
- Control Of An Unmanned Surface Vehicle With Uncertain Displacement And Drag (2016) [19]
- A New Prototype Of Unmanned Surface Vehicles To Survey The Coastal Marine Environment: Design, Modelling And Control (2017) [20]
- Design and Construction of Unmanned Surface Vehicles (2015) [21]
- The Navy Unmanned Surface Vehicle (Usv) Master Plan (2007) [2]
- Pekan Ilmiah Mahasiswa Nasional Program Kreativitas Mahasiswa - Karsa Cipta 2013 (PIMNAS PKM-KC) (2013) [22]
- fishing trawler-like vehicle ARTEMIS, the catamarans ACES (Autonomous Coastal Exploration System) and Auto- Cat (2014) [23]
- Small Rov Marine Boat For Bathymetry Surveys Of Shallow Waters – Potential Implementation In Malaysia (2017) [24]
- Design, Development And Testing Of The Modular Unmanned Surface Vehicle Platform For Marine Waste Detection (2017) [4]
- Development of Modular Unmanned Surface Vehicle for Research and Education (2017) [25]
- Design of a Marine Autonomous Surface Vehicle for Geological and Geophysical Surveys (2018) [26]
- Study On Hydrodynamics Coefficients Of Swath Autonomous Surface Vehicles (Asv) Hullform For Bathymetry Survey Activities (2019) [27]
- Intact stability and seakeeping characteristics of autonomous surface vehicle (asv) using swath hullform to support bathymetry survey activities on the coastal area (2018) [28]

The development show that USV are used in many type of application. Such as surveying, spying, military equipment, waste and pollution, also some of people use as a hobby. This makes the development are always happened every year with new model of combination and variety of technology.

Hullform characteristic can defined by 5 type such as[29]:

- Monohull
  Single hull vessel
- Monohul with Deep Keel
  Single hull with added keel under the vessel
- Catamaran
  Double hull vessel
- Trimaran
  Triplle hull Vessel

SWATH
Small Waterplane Area Twin Hull

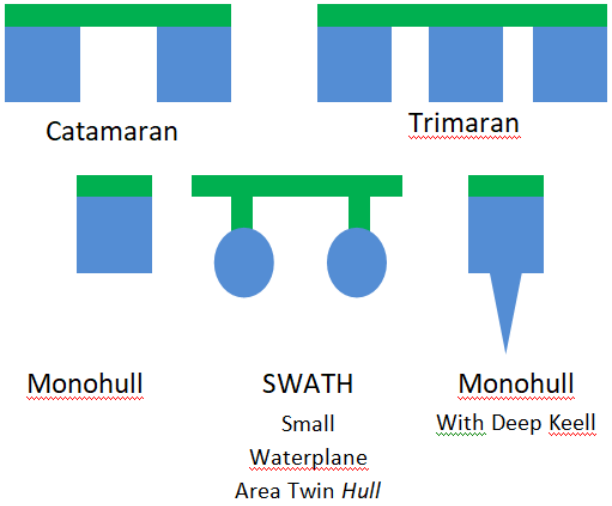

Figure 1: Type of Hull

To solve the calculation and get the stability data from the USV, the needs to do is collect the main dimension of the ship. Main dimension collect by using standard tool to measure the length, the breath, the dept and the height.

Figure 2: Gurindam USV

After collect some data here the data for the 3ft USV

LOA : 80 cm
B : 18 cm
T : 5 cm
H : 16,6 cm

This data also collected from the 3D drawing of USV. This 3D drawing uses Delftship software. With this software we can made the 2 dimensional photograph combine with the main dimension and than we can get the 3 Dimensional ship shape.

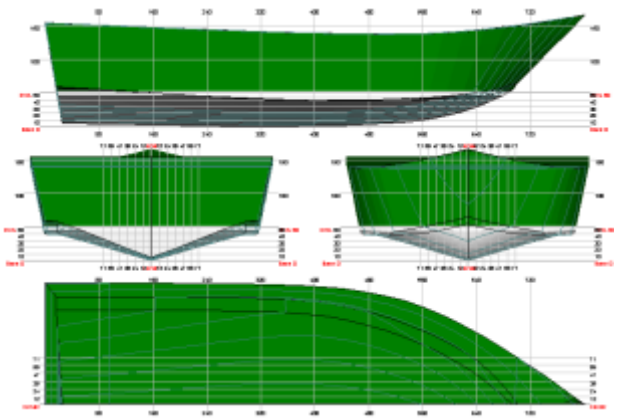

Figure 3: Gurindam USV Lines Plan

Lines plan is a three position projection drawing of the ship from side, front and top. Lines plan also a basic drawing used by the designer before other drawing produce and use to build a ship

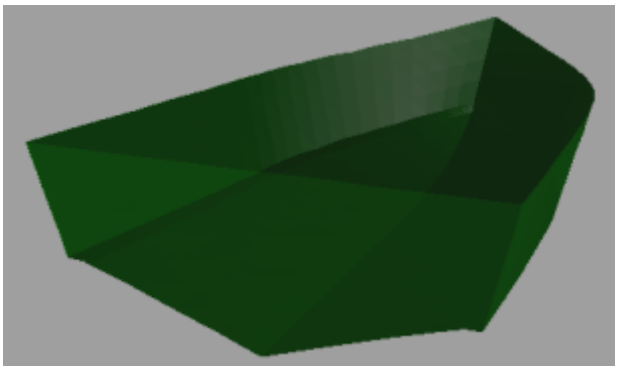

Figure 4: Gurindam USV 3D Model

The 3 dimensional design use to calculate the condition of the ship related with the movement of the ship caused by force from inside weather outside of the boat. Actually the are 3 condition of stability or equilibrium on the ship such as[30]

- Positive Stability
  Positive stability is condition where the center of gravity is below the metacenter so that as soon as the ship heels, a righting arm will begin to develop
- Neutral Stability
  Neutral stability is condition where the center of gravity (G) coincides with the ship metacenter (M), there is zero distance between the two points.
- Negative Stability
  Negative stability is ship condition with a negative metacentric height has its center of gravity (G) above its metacenter (M). This condition can be created whenever weight shifts, removal or additions significantly elevate G

Naval Architect usually prepare this condition by adding or reducing the total weight of ship construction or do some modification so that the condition are always in positive stability. The reason is it can operated normally and no need big effort when unpredictable condition happened.

Table 1: Tabel Hidrostatic USV Gurindam

No	Condition	Result
1	**Draft Amidships cm**	**4.91**
2	Displacement kg	4.174
3	Heel deg	0
4	Draft at FP cm	4.91
5	Draft at AP cm	4.91
6	Draft at LCF cm	4.91
7	Trim (+ve by stern) cm	0
8	WL Length cm	66.74
9	Beam max extents on WL cm	32.07
10	Wetted Area cm^2	1871.86
11	Waterpl. Area cm^2	1742.31
12	Prismatic coeff. (Cp)	0.717
13	Block coeff. (Cb)	0.388
14	Max Sect. area coeff. (Cm)	0.549
15	Waterpl. area coeff. (Cwp)	0.814
16	LCB from zero pt. (+ve fwd) cm	30.1
17	LCF from zero pt. (+ve fwd) cm	30.5
18	KB cm	3.38
19	KG cm	4.91
20	BMt cm	28.96
21	BML cm	123.91
22	GMt cm	27.43
23	GML cm	122.37
24	KMt cm	32.34
25	KML cm	127.29
26	Immersion (TPc) tonne/cm	0.002
27	MTc tonne.m	0
28	RM at 1deg = GMt.Disp.sin(1) kg.cm	2
29	Max deck inclination deg	0
30	Trim angle (+ve by stern) deg	0

The hydrostatic table show the condition of the ship on the water. From the table it can conclude that the displacement of the USV is 4,174kh which it will be use to calculate the stability. From this table we can also know the dimension of LPP, LWL, draft, wetted area, ship coefficient, ect. This result will collect by the researcher to get data and continue the research.

Tabel 2: Equilibrium USV Gurindam

No	Conditon	0	30%	60%	100%
1	Draft Amidships cm	5.83	5.95	6.13	6.36
2	Displacement kg	5.7	5.9	6.2	6.6
3	Heel deg	0	0	0	0
4	Draft at FP cm	6.75	7.09	7.58	8.22
5	Draft at AP cm	4.91	4.81	4.67	4.49
6	Draft at LCF cm	5.76	5.87	6.04	6.28

No	Conditon	0	30%	60%	100%
7	Trim (+ve by stern) cm	-1.84	-2.28	-2.91	-3.73
8	WL Length cm	68.74	69.1	69.64	70.36
9	Beam max extents on WL cm	32.33	32.36	32.42	32.48
10	Wetted Area cm^2	2038.27	2053.8	2078	2104.13
11	Waterpl. Area cm^2	1819.91	1824.63	1832.95	1836.87
12	Prismatic coeff. (Cp)	0.692	0.684	0.674	0.662
13	Block coeff. (Cb)	0.421	0.42	0.418	0.413
14	Max Sect. area coeff. (Cm)	0.628	0.636	0.647	0.661
15	Waterpl. area coeff. (Cwp)	0.819	0.816	0.812	0.804
16	LCB from zero pt. (+ve fwd) cm	32.97	33.55	34.34	35.27
17	LCF from zero pt. (+ve fwd) cm	31.01	31.2	31.48	31.91
18	KB cm	3.94	4.03	4.15	4.33
19	KG fluid cm	3.93	3.97	4.02	4.08
20	BMt cm	22.96	22.22	21.22	19.98
21	BML cm	100.43	97.75	94.28	88.89
22	GMt corrected cm	22.97	22.28	21.35	20.23
23	GML cm	100.44	97.81	94.41	89.15
24	KMt cm	26.89	26.24	25.35	24.28
25	KML cm	104.33	101.72	98.34	93.09
26	Immersion (TPc) tonne/cm	0.002	0.002	0.002	0.002
27	MTc tonne.m	0	0	0	0
28	RM at 1deg = GMt.Disp.sin(1) kg.cm	2.29	2.29	2.31	2.33
29	Max deck inclination deg	1.5792	1.9538	2.4981	3.1998
30	Trim angle (+ve by stern) deg	-1.5792	-1.9538	-2.4981	-3.1998

Equilibrium is condition where the ship gets the equality on the calm water condition. This condition must known by the owner or operator so that if there are any interruption force from inside or outside of the USV. The different condition on the ship are almost 3-8% by condition of the fuel. The used of full because the amount of fuel will decrease along the used of the ship. From table it's also shows that the condition of drat are follow the condition of the weight of fuel. The more mass of fuel, the more draft on the FP will increase. Than the more draft on the AP will dicrease. It can also conclude that the ship in on condition trim by the bow. This condition take on the calm water condition and on zero speed. So if it the data takes on the on going USV, the result will be different because there are a power and speed adde.

The GZ curve is a curve too show the GZ condition on the each of loadcase above the ship. Loadcase is a load or item installed of the ship weather it is fixed or flexible such as engine, weight of empty ship (lightship) or the fuel of the ship. Maximum righting arm (GZmax) is the the result by the the vertical miss alignment of the buoyant and the weight of the ship on the maximum rank of the internal moment. It's can said the peak of the curve of intact static stability[31] . Maximum righting arm will be inline with the maximum righting moment. The more righting moment value, will be the less the ship will capsize. The position of the maximum righting moment happened, will be the position of the angle of GZmax. And the angle of GZmax usually will appear on the stability calculation.

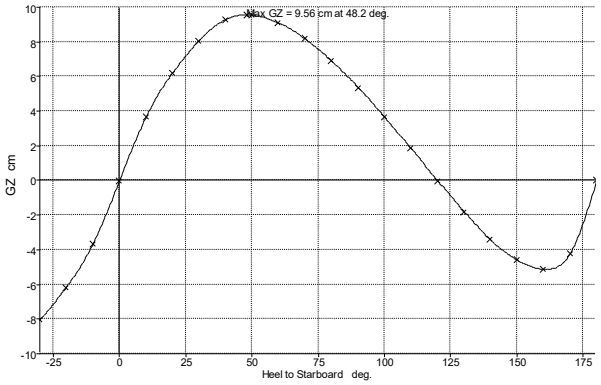

Figure 5: 0% Condition of Fuel Tank

The 0% Condition showed on the figure is a condition where the tank of fuel engine on the lowest position (on this case, the researcher set by 0). From the figure it's show that the Max GZ = 9,6 cm at 48,2 deg.

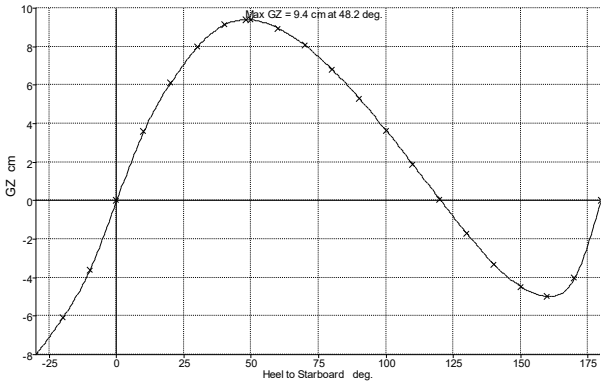

Figure 6: 30% Condition of Fuel Tank

The 30% Conditian showed on the figure is a condition where the tank of fuel engine on the 30% from maximal capacity. From the figure it's show that the Max GZ = 9,4 cm at 48,2 deg.

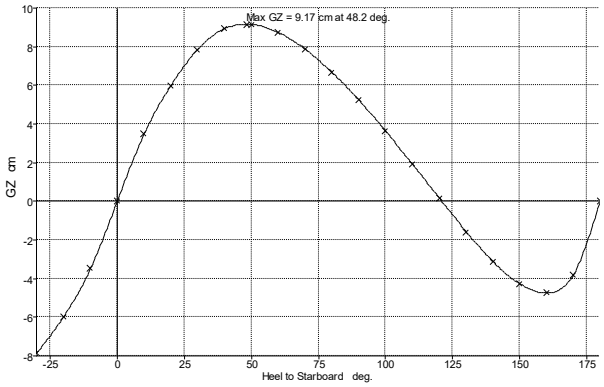

Figure 7: 60% Condition of Fuel Tank

The 60% Conditian showed on the figure is a condition where the tank of fuel engine on the 60% from maximal capacity. From the figure it's show that the Max GZ = 9,17 cm at 48,2 deg.

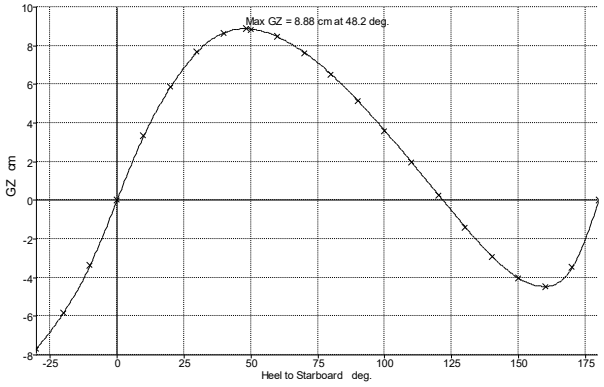

Figure 7: 100% Condition of Fuel Tank

The 100% condition showed on the figure is a condition where the tank of fuel engine on the 60% from maximal capacity. From the figure it's show that the Max GZ = 8.88 cm at 48,2 deg.

The simple analytical that can be show from the figure is, the more fuel capacity, are the less good condition of the stability of the ship. Shown by the decreasing of maximum GZ on the same condition of maximum angle of GZ. This could be happened because of the position of the fuel tank on the front of the USV.

From the carracter of the ship, the researcher must prepare the next research that can modified or upgrade the hull, the mass or weight distribution on the USV so that the performance off the can be maximized.

4.0 CONSLUSION

From the research it can concluded that the USV has a maximal GZ 9,56cm at 48.2 deg in mimimal weight and maximal GZ 8.88cm at 48.2 deg at the maximall weight of the ship. From this result, it can concluded that the more weight added on the fuel tank (front position) the more unstable condition of the ship. Or, it's need a fixed ballast on the AP area to get the more stability on the USV

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