Conceptual design of “S-39” aircraft carried submarine

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Abstract. A “Submarine” is a warship with a streamlined hull designed to operate completely submerged in the sea conducting missions undetected in hostile waters. Since early 19th century to recent times. Submarines always have been a trump card in most wars. As the world progress in development of defence systems like UAV and UCAV, which are aircrafts without human pilot aboard, capable of conducting surveillance and combat operations and the UUV can conduct surveillance underwater for mapping, geological study’s etc tasks. What if UAV and Submarine technology can be combined in a single vehicle? Well then, this study serves all the above criteria. “S-39” is an aircraft carried submarine which a Sindhughosh-class submarines capable of carrying aircrafts or UAVs into enemy lines, launch them from the submarine itself and recover them when the mission is done and leave the area. At a time, it can carry 3 IAI HERON or MQ PREDATOR or it can carry other UAVs the number of them varies according to their size. Also, it carries armament, equipment and fuel for 3-4 rounds of each UAV i.e. each UAV can conduct 3 missions in 1 duration of the submarine’s operations time of 2-4 months. The main objective of this study is to carry combat UAVs behind enemy lines undetected, then to launch stealth surveillance mission or surprise strikes on enemy also the range of the UAVs will be increased as the communication with the UAVs will be via the submarine or a communication relay torpedo (if necessary) hence the UAV control centre will be harder to detect by enemy.

1. Introduction

A “Submarine” is a diving ship with a streamlined hull designed to operate completely under the sea and conducting missions undetected in hostile waters. The first practical submarine design was made during the 19th century, and was considered by various countries. Submarines were first proper use of submarine was during World War I. Military used it for attacking enemy surface ships, reconnaissance, blockade running, attacking other submarines. They use a propeller or pump jet at the rear portion of the submarine along with various hydrodynamic control fins for manoeuvring and turning [1-3]. Figure 1 (a) depicts the first submersible “Drebbel” propelled by oars was designed and built in 1620. Figure 1(b) shows the first military submarine “Turtle” propelled by diesel was constructed in the year 1775. It was the first submersible to use screws for propulsion. The recent submarines were propelled either by either diesel or by nuclear fuel. The “S-39” model discussed in this study has diesel electric propulsion system.
2. Introduction to UAV

An unmanned aerial vehicle (UAV) also called as drone is an aircraft without a human pilot on it. UAVs is a part of an unmanned aircraft system (UAS) and is based on function between a ground based controller and communications system between the UAV and the pilot flying it by the controller on ground. Initially drones were used for practice firing for the battleship’s guns. The earliest attempt at a powered UAV was A. M. Low’s "Aerial Target" in 1916. Nikola Tesla described a fleet of unmanned aerial combat vehicles in 1915. Advances followed during and after World War I. In 1990s, the UAVs saw its first full proof actions during the 1991 Gulf War and they were manufactured by a Israeli based company. They demonstrated the possibility of cheaper, more capable fighting machines and that could be deployed in great danger zoon without risk to any pilots. The initial prototypes were included as a surveillance aircraft but some of them like the General Atomics MQ-1 Predator armaments carrying feature which could armed with air to ground missiles [4]. In 2013 most of the countries developed and used their own UAVs of wide variety according to their needs.

2.1. IAI Heron

The Heron UAV System is based on advance technology and is a long-endurance medium-altitude system, which has a full automatic take-off and landing feature. It provides intelligence to national agencies by flying deep into enemy territory and has a wide operational radius. The Heron has space for 250 kg which allows customer fix customises equipment’s and can fly for 52 hrs continuously for reconnaissance and surveillance to provide customer with real time information’s. Herons are also deployed with the Indian defence forces to perform high altitude ground surveillance and maritime patrol and anti-piracy missions [5]. India has recently renewed its interest in buying these unmanned aircrafts from Israel to increase the security along the borders of Pakistan and China. A deal has been made with Israel Aircraft Industries (IAI) for the purchase of 50 advance Heron armed and non-armed aircraft. The Heron currently in service is shown in Figure 2.

2.2. MQ 1 Predator

MQ-1 is a designated Predator Unmanned Aerial System (UAS), which was initiated in 1994 program under Advanced Concept Technology Demonstration (ACTD) and since then have been eagle for most of the world’s leading defence organisation for surveillance and ground engagement [6]. MQ1 as shown in Figure 3 is the armed version that followed the RQ-1. The design is based upon modified Gnat 750 UAV. India is still planning to crack a deal on these predators and set to bring 15 of them by 2021.
Figure 3. MQ 1 Predator

3. Design of components

3.1. Design of pressure hull
Modern submarines are mostly of shape of a cigar. The design was first used in the submarines during the period of 19th and 20th century was also called as “teardrop hull” configuration. This design configuration helped the submarine to reduce the hydrodynamic drag that are generated when the submarines are submerged, but it decreases the sea keeping capabilities hence increasing the drag is while moving on the surfaced of water. Since there were a lot of limitations in the propulsion systems in early submarines, they were forced to operate mostly on the surface for a major period. During late World War 2 period, with the technological advancement, faster and longer surveillance operation equipments on ships and long-range aircraft surveillance missions forced the submarines to stay submerged in deep ocean for most of time to avoid detection. Then it was during this time that hull designers reintroduce the teardrop configuration again which helped to reduce drag and noise. In recent times, military submarines outer hull has layers of sound absorbing plates to reduce detection by sonar equipments. The pressure hulls for a deep diving most of the submarine are mostly spherical configuration because it allows a uniform distribution of stresses even at great depths.

The pressure hull is mostly constructed by thick high strength steel along with a complex structural design to distribution the stress or pressure uniformly and has high strength reserve. These pressure hulls are separated with the help of watertight bulkheads which divides the submarine into several compartments according to required design. There are also examples of submarine which have more than two hulls in a submarine, like the Virginia class [7-8].

WWI submarines had hulls made of carbon steel which can go up to maximum depth of 100 metre. During WWII, high strength alloy steel was used for the 1st time which allowed a depth of 200-metre. High strength alloy steel remains a primary material for pressure hulls for most of submarines even today which can dive up to 250 or 400 metre depths and its depth cannot be increased on military submarines without compromising the design.

Considering the fig 3.1 the thin layer near “C” is the outer hull used to maintain the submarine shape with a thickness of 12 cm made of High Strength Steel (HSS) of Mild Steel. The cross section of the pressure hull has diameter of 6.7m and has a thickness 30 cm of as shown in Figure 4, which can withstand the necessary stress and have proper stability and strength to handle the weight of a large aircraft hangar placed on the deck when subject to pressures and other forces at the allowable depth of 300 m depth. The pressure hull will be made by alloy of HSS (HSS 67%). In between outer hull and pressure hull the space will be filled by ballast tanks and circular beams of t section to provide strength and distribution of stress uniformly on pressure hull [9].
3.2. Design of Hanger

Located approximately near the middle portion of the submarine, on the top deck is cylindrical water sealed hangar for the uavs or aircrafts of dimensions 29 m long and 2.8m in diameter and of height 4 meter. It has the capacity of carrying 3 IAI HeronUAV or MQ Predator UAV and its equipments. The hanger is fitted with data transfer cables with which the data gathered by the uav can be transfer to the submarine data storage and then send back to base in encrypted format for analysis. It’s also fitted with a maintenance scanner which scans the uavs for inspection of any damage and sends its data to the base so that the condition of uavs can be checked. The hanger can be open from front side only through a door placed for this purpose, which can be opened by hydraulic mechanism by remote or manually by turning a large hand wheel placed outside of the hanger. The wheel is connected by a rack and spur gear. The door must be made waterproof and the hanger should not conation any moisture, dust or other impurity because once submerged the submarine the hanger will be totally for a long time till the submarine resurface. Till this time if there is any contaminates in the hanger then it may damage the systems, can cause corrosion to metal parts, can choke the fuel and data transfer system in hanger and a lot of other problems. This will cause problem during the various operations. Therefore, the door is made waterproof with rubber gasket of 51 mm thickness. This gasket will also be able to withstand pressure of water on the doors and hanger joint edges preventing the door from getting open due to pressure at deep depths. The hanger also has integrated dust, impurity and moisture removal system which will prevent any contamination and keep the hanger dry and ready to use. The line sketch of the hanger is depicted in Figure 5.

Figure 4. Cross-section of hull

Figure 5. Cross-section of hanger
Since the submarine is mainly used for UAV launch there for various types of UAVS may be loaded on in it according to operations and mission requirements. Each UAV is of different size, shape, weight and can carry different armaments. Therefore, different customization hanger is required for different UAV so the hanger must have some replaceable type of system so the different hanger according to UAV can be fixed on the submarine since making a full submarine for different UAVS will be a costly process. Therefore, the hanger will be fixing with the help of slide system for easy replaceable system in minimum time. As the hanger is sliding over the submarine body and screwing from inside it leaves no week points on the top surface like the joint between bolt and nut. At deep seas due to pressures the joints will fail therefore if we join the hanger with the help of nut and bolt from outside surface of the submarine then likely at certain depth the hanger will get separate from the main body causing severe damage beyond repair. But it can we can prevent this mishap by using slider system and internal locking systems. The slides do carry the armaments, equipments and fuel for 3-4 rounds of each UAV i.e. each UAV can conduct 3 missions in 1 duration of the submarine, inn total it has to carry addition 0.512 tons of armaments and 378.5 litters *9 times i.e. 4.608 tons and 3406.5 litters of fuel. The fuel will be first heated up to a desired temperature before being pour in UAVs so that the warm up time of engine can be saved.

3.3. Design of Catapult launch system
An aircraft or a UAV of the above mention type need a run way to take-off. Now generally the runways are long such as 5000 m to 1 km but a submarine cannot be so long to accommodate such long runways therefore to launch the UAVS for the submarine a catapult launch tack of length 28 meter and width 2 m is designed which will function with compressed air will be placed below the forward deck of the submarine [10-11]. The launch track can change its angle of elevation up to 15° degree with the help of hydraulic collapsible stand supporting it. Beneath the catapult track there are 4 high pressures air flasks of that are connected in parallel order to a piston. As the compressed air pushed the piston forward into the tube with a maximum velocity, the carriage connected to the piston also moves at the speed hence the UAV mounted on the top of that carriages also moves along with it and reach the take-off speed at a minimum distance and time. To launch time for an UAV is 5 minutes and it is retrieved in 3 minutes.

3.4. Design of storage system
The major task here is how to fit in all three IAI heron UAV of overall length of 8.50 m and wingspan of 16.60 m inside the hanger of dimension 29m, 5m, and 5m as shown in Figure 6.
From Figure 6, the distance between “O” and “B” is 1.5 m and between “B” to “A” is 6.90 m. As the support from the tail to the main body does not have any complicated parts or interior equipments so it can be collapsed from $P_1$ to $P_2$ which makes the UAVs compressed length from 8.50 m to 6.8 m. The wings due to its complexity cannot be compressed, but it can be folded by 90° vertical along the black line on the wing as shown in Figure 7.

3.5. Design of mechanical crane
Stowed in a recess compartment opened on the forward port side, below the deck, is a collapsible mechanical crane which will be used to retrieve the submarine's UAVS from the water surface after their landing on water after completion of mission. The crane has an electrically operated hoist which can lift approximately weight of 4.5 t. It is raised mechanically to a height of 8 m by a motor inside the submarine stored below the forward port side. The boom can stretch out to a length of 11.8 m. A coating of anechoic absorbent prepared by mixing of asbestos gum along with various adhesives is applied to the hull [12]. This mixture helps to diffuse and absorb enemy sonar pulses and helps to decrease the reverberation intensity from the submarine's internal machinery or other noise therefore making detection of the submarine more difficult when submerged.

4. Conclusion
The conceptual design of unmanned under water aircraft carrier is made and its orthographic views are shown in Figure 8 for reference.

The specification of the submarine is listed in Table 1.
Table 1. Specification of the submarine

| S. No. | Parameter                        | Specifications       | Motors type       | Rating (hp) | Nos. |
|--------|----------------------------------|----------------------|-------------------|-------------|------|
| 1      | Overall size (LxBxH) in ‘m’      | 75.6 x 9.6 x 11.6    |                   |             |      |
| 2      | Dive depth in ‘m’                | ≈ 250                |                   |             |      |
| 3      | Propulsion                       |                      | Diesel-electric   | 3,650       | 2    |
|        |                                  |                      | Main motor        | 5,900       | 1    |
|        |                                  |                      | Auxiliary motors  | 204         | 2    |
|        |                                  |                      | Economic speed    | 130         | 1    |
| 4      | Speed                            |                      | Condition         | Magnitude   |      |
|        | In surface                       | 12 mph               |                   |             |      |
|        | Under submerged condition        | 20 mph               |                   |             |      |
| 5      | Displacement                     |                      | Under submerged condition | 2,563 T     |
|        | UAVS                             | 3                    |                   |             |      |
|        | Type 53-65 torpedo               | 4                    |                   |             |      |
|        | CS-S missile                     | 8                    |                   |             |      |
| 6      | Armament                         |                      | DM-1 mines in lieu of torpedoes | 24   |
|        | 14 cm/40 Type naval gun          | 1                    |                   |             |      |
|        | 25 mm triple- mounted            |                      |                   |             |      |
|        | Type 96 autocannon (9 barrels total) | 2    |

The unmanned under water aircraft carrier is a total new concept in unman weapon system industry, and since the world is now moving quickly towards unmanned combat systems soon this type of project will be required and will be in demand in all country to keep up the arm race. Therefore, if INDIA can have such type of projects copy rights like US then INDIAN weapon industry will be in great advantage and the level of INDIAN defence can be high.

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