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Improved Dive Plane Design for the Taniwha Submarine

Sanjay Surendran, Christopher Walker, Benjamin Pocock and Iain Anderson, The University of Auckland, New Zealand

Background

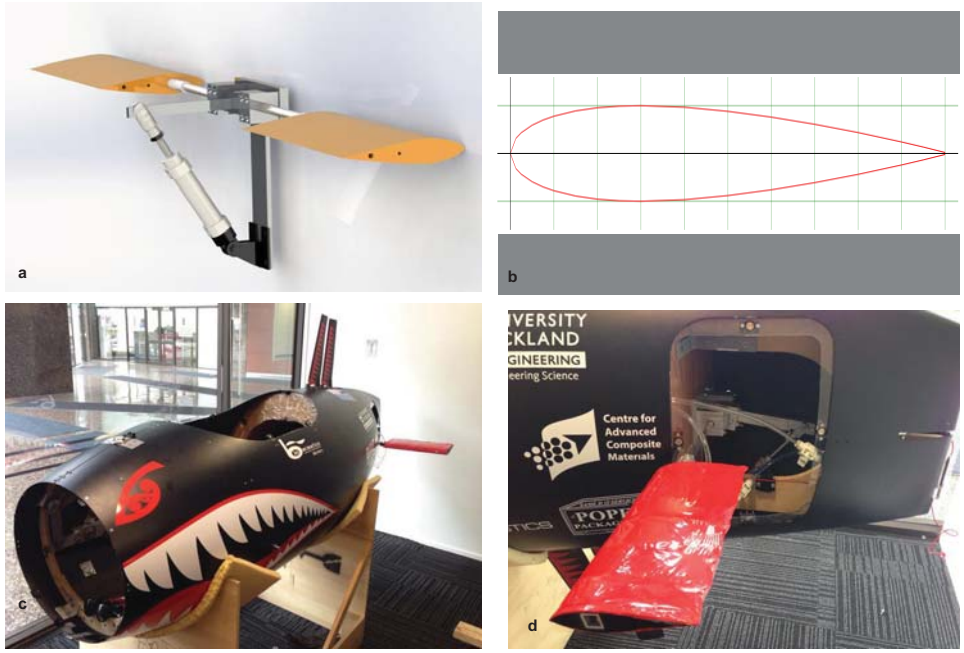
The human powered submarine Taniwha is the Southern Hemispheres pioneering entrant into the International Submarine Races. The Taniwha is unique compared to conventional submarines as it utilises a non-propeller propulsion system, this proved effective and led the Taniwha to be awarded the prize for best non-propeller performance at the European International Races in June 2014 [1].

However this race highlighted unforeseen problems with the design. The Taniwha utilised a dive plane system located forward of its centre of buoyancy. Meaning that when the dive planes are used they create a positive feedback system as the drag on the dive plane exerts a moment in the same direction as the movement of the submarine which if not counter acted by the pilot will cause the sub to continue to rise or dive. Another issue was the system utilised a string pulley driving mechanism which had to be kept taut throughout operation which unfortunately failed during the EISR event.

The Taniwha before the new dive plane system was installed

Method

To improve the dive planes three main objectives were created. Firstly to shift the dive plane mounting to behind the centre of buoyancy, resulting in the increased drag creating a moment in the opposite direction to the level adjustment and therefore a negative feedback system. Secondly a new driving mechanism to be used instead of the string and pulley system. And lastly to improve the design of the fins to a more streamlined and rigid design.

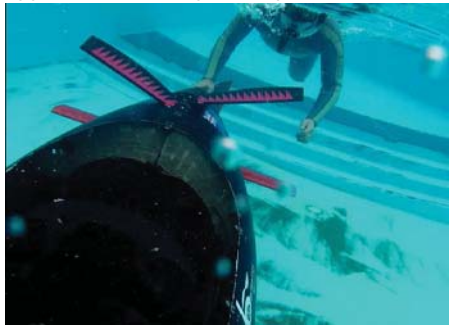


(a) CAD of proposed new dive plane system, (b) ,(c) The current form of the Taniwha with dive planes mounted at the rear,(d) New mounting system for the dive planes in the Taniwha

The placement of the dive planes was shifted to the back of the submarine just behind the propulsion system of the submarine. This places the dive planes to the stern of the centre of buoyancy and hence it will create a negative feedback system allowing the sub to naturally level out when the dive planes are returned to the neutral position. The new dive plane system utilises a simple master and slave piston hydraulic system. The handle controlled by the pilot is attached to a cylinder which is connected to another cylinder that then drives the dive planes using an arm clamped to a stainless steel rod that connects the two dive planes. The new dive planes are based on a NACA 0010 aerofoil profile [2]. This profile creates a large lifting or diving force and only takes 8 degrees of rotation either way to generate maximum force which is well suited to the limited motion of the submarine pilot.

Results and Conclusion

The new dive plane system was mounted into the Taniwha and taken to the pool to test the system in an underwater environment. Due to the nature of the submarine it was not possible to generate empirical data on the effectiveness of the system as there are many unknown variables. However in a purely qualitative sense the system appeared to work perfectly.



In conclusion while the mechanism itself appeared to work very well, an improved pilot interface and feedback system is needed. But the Taniwha is well on its way to taking on the world in June 2015.

References

[1] European International Subrace (EISR); 2014; http://www.subrace.eu/

[2] National Advisory Committee for Aeronautics (NACA); Model 0010; http://airfoiltools.com/airfoil/details?airfoil=naca0010-il

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