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2nd generation wobble watercraft

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ABSTRACT

Purpose: The main objective of the present work was to develop a new type of human-powered watercraft for sports activities on still water bodies, such as reservoirs and lakes.

Design/methodology/approach: The power for the watercraft is provided by the body of its operator who sets the propulsion mechanism in oscillating or rocking motion. The oscillating or rocking motion of the mechanism is transmitted to underwater propelling elements. A prototype has been built and tested. A computer model of this craft was constructed using Solidworks 2014 CAD tool and strength verification calculations were carried out in MSC.MARC software.

Findings: The prototype consists of a float in the form of a surfboard and a moving mechanism which incorporates a welded high-strength aluminium alloy frame. Great effort was put into finding an appropriate shape of the propelling element.

Practical implications: Multiple elements of various shapes and sizes have been tested. Their verification with the aid of CFD analysis in Xflow software was followed by physical testing.

Originality/value: . Once the suitable type, shape and size of the propelling element were identified, the elements were applied to the craft. Successful testing of these 2nd generation prototypes was completed this year.

Keywords: Wobble; Vessel; CFD analysis; Testing of prototype, Sport; Fun

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ANALYSIS AND MODELING

1. Introduction

As part of its research activities, COMTES FHT is working on developing unconventional transport vehicles for sports and leisure activities. Design and material solutions are developed for new-type human-powered craft. The power is provided by the human body which sets the propulsion mechanism of the craft in oscillating or rocking motion. The movement of the system is transformed to either rotational or translational movement. Generally, these can be transformed to other types of movement as well but the additional transformation would entail losses. The use of wobble systems activates muscles throughout the operator's body (Fig. 1). The present paper describes the utilization of the wobble system as a means of propulsion of a watercraft. Prior to the development stage, a literature search on the state of the art of non-traditional watercraft was conducted. [1]-[6]

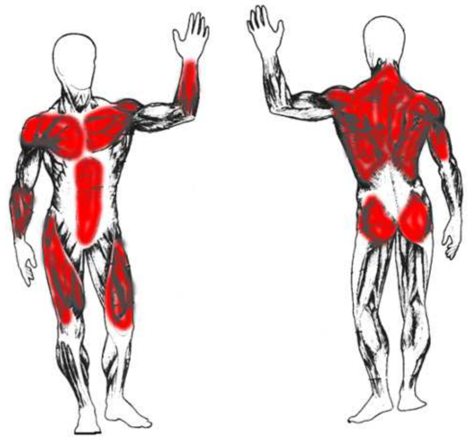

Fig. 1. Muscles activated by the use of the wobble system

2. Present-day human-powered watecraft

Today's human-powered watercraft intended for recreational use on still water bodies, such as reservoirs, lakes or still rivers, can be categorized into boats, pedalos, surfboards and non-traditional watercraft. The watercraft developed by us belongs to the last category, alongside the other existing types, such as aqua zorbing balls, water bird vehicles and others. [7, 8].

Fig. 2. Aqua zorbing [5]

Aqua zorbing can be described more accurately as a fun activity and its use for transport is not efficient. Riding a water bird vehicle is a sports discipline but when the rider ceases to provide the power, the craft sinks. The main purpose of non-traditional watercraft is to offer new experience and fun, to develop new forms of agility, achieve higher speeds or deliver other attractive aspects of sailing.

Fig. 3. Water bird [8]

3. Wobble watercraft

This newly-developed watercraft belongs to the non-traditional category and its concept builds on the strengths of pre-existing watercraft types. It is propelled by the wobble system and stays afloat thanks to a surfboard. A prototype of this craft was developed and tested using strength analysis and CFD analysis. Its concept draws on the experience with the 1st generation wobble watercraft which relied for its motion on a system of elastic flippers. The 2nd generation wobble watercraft is shown in Fig. 4. It comprises a float and a moving structure. The float is a factory-made component with a defined load capacity. Attached to the float is a structure which is set in oscillating motion by the rider's swaying forward and backward. The ergonomics of the structure has been adjusted to allow the rider to use muscles in all parts of their body for powering the watercraft. The moving structure comprises a support frame with attached propelling elements. The latter are located under water and connected to the steering mechanism which controls their angle. The propelling element tilt angle is dictated by the forward and backward movement of the steering rod. The rod is mounted on the front part of the moving structure. In this manner, the stroke efficiency can be optimized with respect to the travel speed. The tilt system also fulfils the braking function. When the propelling elements rotate to 90° angle with respect to the direction of travel, they slow down the watercraft. Attached to the moving frame are tread plates with anti-slip surface. The moving structure is a welded frame from high-strength aluminium alloy. It is supported in bearing blocks mounted on the float. Stabilizing elements fitted between the float and the aluminium frame enhance the rider's stability on the watercraft and limit the angles reached in the rocking movement. In simple terms, the stabilizing elements are similar to torsion bars. Steering is aided by a rudder mounted on the float. [2],[3]

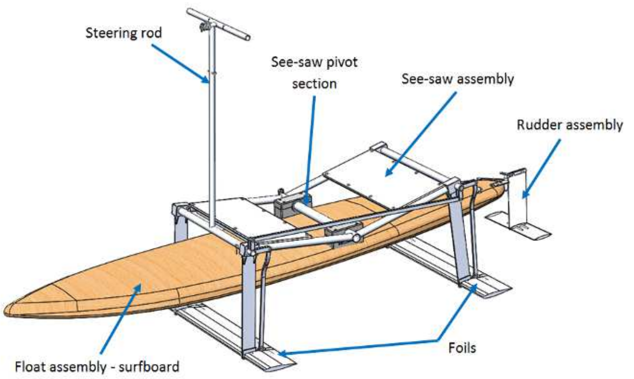

Fig. 4. CAD model of the wobble watercraft

4. Simulation of propelling element efficiency

Flow simulations have been used for identifying suitable shapes of propelling elements. The shapes were optimized using CFD analysis and the XFlow software. XFlow relies on the Boltzmann equation to model fluid behaviour at mesoscopic scale using non-equilibrium statistical mechanics. The Boltzmann equation is able to reproduce the hydrodynamic limit and can also model rarified media with applications to aviation, space industry, microfluidics or even near vacuum conditions, see Fig. 5. [9]

Fig. 5. Schematic representation of the XFlow solver [9]

XFlow focuses on simulations of underwater moving parts with forced or constrained behaviour, such as the propelling elements in this case. Using CFD analysis, the distribution of pressure and forces exerted by the flow on functional surfaces can be studied, as well as fluid velocities, reaction forces and other aspects.

The criteria chosen for identifying the optimum variant were the propelling force and flow velocity. In simple terms, the objective was to achieve the highest possible speed of the craft using the lowest possible propelling force. Another aspect of interest was the effect of the first propelling element upon the second one, i.e. the question whether the flow from the first propelling element reduces in any way the efficiency of the second one (Figs. 6 and 7).

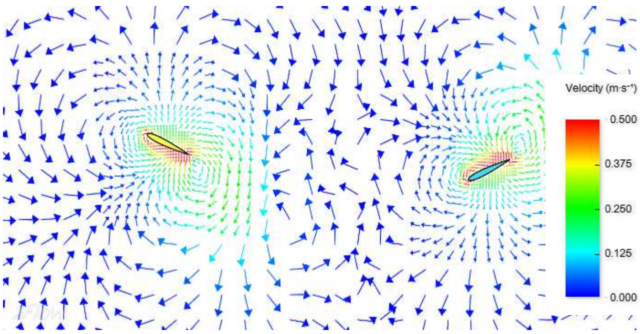

Fig. 6. Flow velocities after 10 seconds

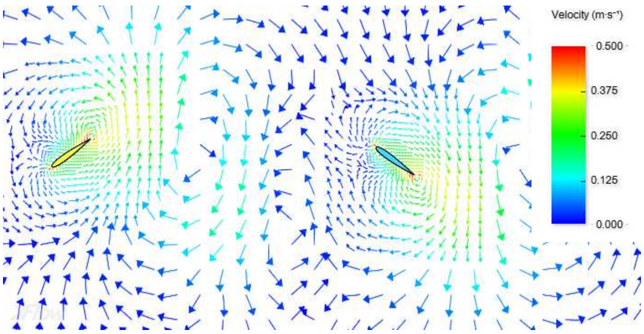

Fig. 7. Flow velocities after 15 seconds

The development process involved testing of several alternative propelling elements, such as flippers, foils, paddle wheel and screw propeller. As rotating propelling elements (paddle wheel and screw propeller) proved impractical due to low rocking frequency, virtual testing continued with flippers (Fig. 8.) and foils (Fig. 9.). The following images show designs of propelling elements based on the simulation.

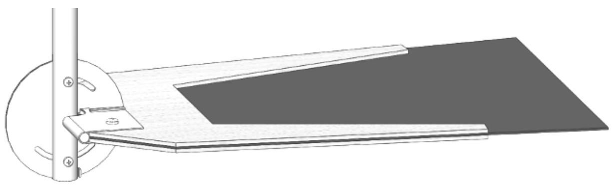

Fig. 8. Flipper as a propelling element

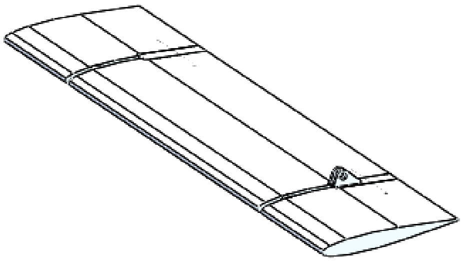

Fig. 9. Foil as a propelling element

After the suitable propelling element type was identified, i.e. foils, changes were made to the design and a strength verification was carried out. This prototype does not feature the final product design. Its main purpose was to prove the function and the ability to move across water surface.

5. Prototype testing

Prototype trials took place on a still surface of a lake (Fig. 10). The key was verifying the craft function and identifying aspects for potential improvement. The prototype is intended for one rider with a body weight of less than 80 kg. The capacity of the watercraft is governed by the capacity of the float.

Fig. 10. Prototype testing

Fig. 11. The prototype

The prototype (Fig. 11) testing proved the function of the mechanism but also prompted further adaptation, e.g. new foil designs. Another objective of the testing was to validate the numerical simulations. This provided new findings on the movement of this watercraft.

6. Conclusions

This article describes a wobble system and its use on a human-propelled watercraft. A watercraft prototype has been developed, constructed and successfully tested on a still water surface. It comprises an aluminium structure, a float and stabilizing elements.

Testing was aimed at verifying the function and gathering input information for further development. Studies of new versions for multiple riders and a family watercraft for recreational purposes have already been drafted.

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