PROOF OF CONCEPT AND TESTING OF

TREADLE-POWERED FIN PROPULSION BOAT

DESIGN RESEARCH SEMINAR

SUBMITTED BY

NIRMAL P J 176130009

SAIJITH M S 176130007

ANUSHREE BANERJEE 176130012

VINOD LOUIS JOSEPH SWAMY 176130013

GUIDE : PROF V P BAPAT

IDC SCHOOL OF DESIGN

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

2019

DECLARATION

I declare that this written report represents my own idea in my own words,and where other's ideas or words have been included, I have mentioned the original source, I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any ideas, data, facts or source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also penal action from the source from which proper permission has not been taken, or improperly cited.

Anushree 176130012
Nirmal P.J. 176130009
Saijith M.S. 176130007
Vinod Louis Joseph Swamy 176130013

Master of Design
IDC School of Design
Indian Institute of Technology, Bombay

Approval Sheet

This project title “Proof of concept and testing of pedal-powered fin propulsion boat” is prepared and submitted by Anushree, Nirmal, Saijith and Vinod for the partial fulfillment of the requirements for the degree of ‘Masters in Design’ in Industrial Design. It has been examined and is recommended for approval and acceptance.

Sign of Project Guide
Prof. V P Bapat

Acknowledgement

We would like to express my gratitude to my guide, Prof. V P Bapat for his guidance and support through the project. His suggestions and instructions were what helped me to steer this project in the right direction and push myself to try and come up with new ideas and solutions. We are also highly grateful to my friends, fellow classmates and parents for encouraging me when we felt lost and constructively adding to my project with their valuable feedback in every possible way.

NIRMAL P J 176130009
SAIJITH M S 176130007
ANUSHREE BANERJEE 176130012
VINOD LOUIS JOSEPH SWAMY 176130013

Outline

1. Abstract
2. Mechanism
3. Human Factors and form
4. Variable Factors
5. Fabrication
6. Conclusion

Abstract

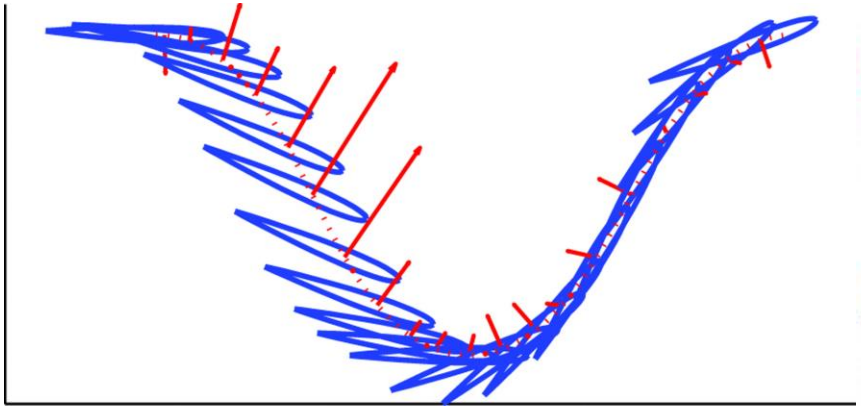
In this research paper we talk about design and fabrication of a boat propulsion inspired by the biomechanics of a caudal fin of a fish. Various mechanism and forms generation has been explored to finally create a 1:1 scale proof of concept to test the functioning of the design. Experiments have been conducted to check the performance of the the aquatic propulsion system and how it can be further improved.The aim was to develop a simple and efficient system inspired by biological system which has an edge over the conventional screw propulsion.

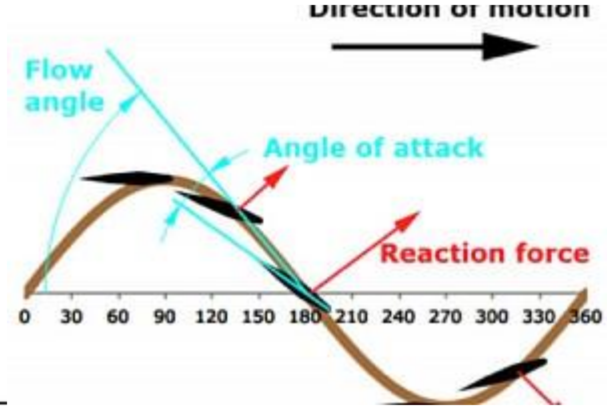
Fish Locomotion

The studies have shown different types of motion which fishes use to create thrust.Most fish generate thrust by bending their bodies into a backward-moving propulsive wave that extends to the caudal fin, a type of swimming classified under body and/or caudal fin (BCF) locomotion. The propulsive wave traverses the fish body in a direction opposite to the overall movement and at a speed greater than the overall swimming speed.[Kyu-Jin Cho, Elliot Hawkes, Chris Quinn, Robert J. Wood]

Depending on the envelope shape of this bending wave, different modes can be distinguished: These are anguilliform, subcarangiform, carangiform and thunniform. When the amplitude is large along the whole body, the swimming is of undulatory type and is called anguilliform; if the undulations are confined in the posterior part of the body the swimming is said to be carangiform. Ultimately, when the amplitude is significant only at the tail, the swimming is oscillatory. In this mode, the thrust is primarily generated by the horizontal tail flapping of marine mammals, like whales or dolphins, or by the oscillations of the vertical caudal fin for fishes like sharks or tunas. This family of swimmers, referred to as thunniform, is characterized by a streamlined rigid body, a crescent moon-shaped tail attached to the trunk and a strongly reduced cross-section at the peduncle that attaches the tail to the body.

For our study, thunniform is the mode of swimming bio-mechanism which has been adapted to create a proof of concept, which is achieved by creating oscillatory motion in the flap by threddle motion of legs by the driver.





[http://jeb.biologists.org/content/213/1/63]

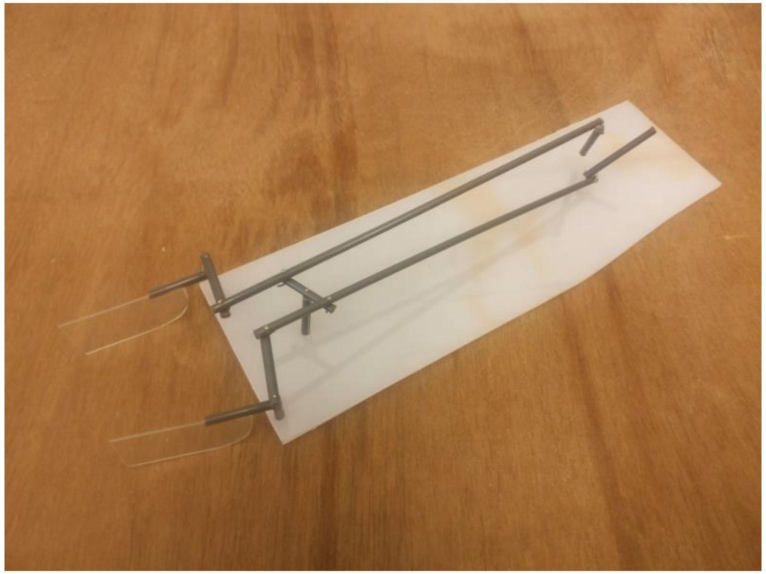
[https://www.huygens-engineers.com/nieuws/uitnodiging-in-afstudeercommissie-aan-de-tu-delft/]

Advantages of Caudel inspired propulsion/Flapping foil propulsion

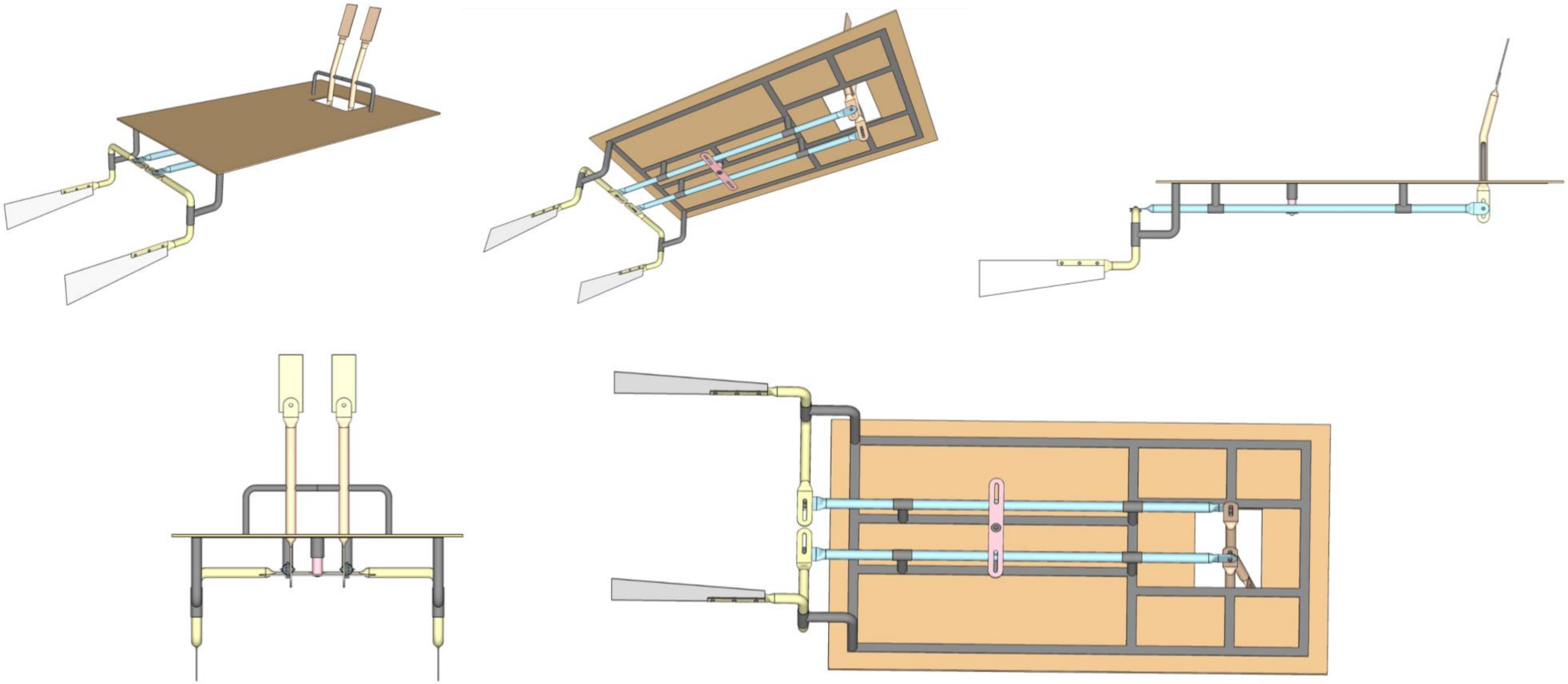
The treadle motion has a lot of advantages .It is much more smoother and creates less splashing of water which would lead to lesser noise Although it is not ideal for high speed propulsion. The sinusoidal motion creates less drag in the the water at the same same time pushing large quantity of water.

Mechanism

While adopting the thunniform mode of swimming the mechanism for a human powered boat the aim was to create a mechanism which requires minimum effort by the driver to turn into maximum efforts. Converting back and forth motion of the foot powered treadle motion into oscillating motion of pair of fin submerged under the boat, also called the ***flap foil propulsion***.The oscillating motion creates sinusoidal waves inside the surface of water hence propelling the boat in the forward direction. Creating details of the mechanism which can be easily fabricated by a team of 4 and tweaked for experimentation.
Factors like adjustability of the seat and the position of the fin had to be added .



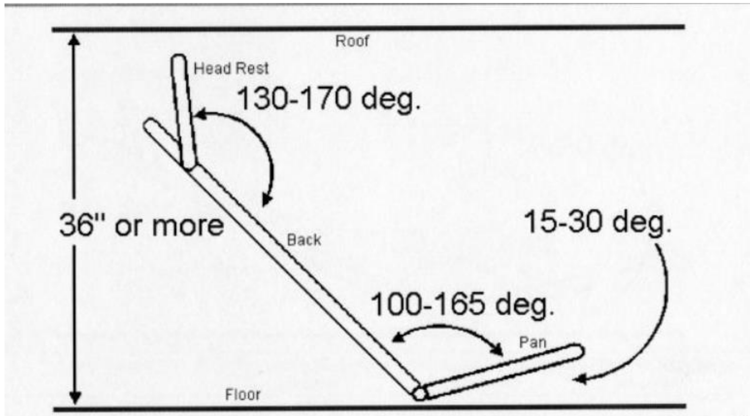
[scaled mockup of the mechanism]



[3D visualisation of the mechanism in sketchup model]

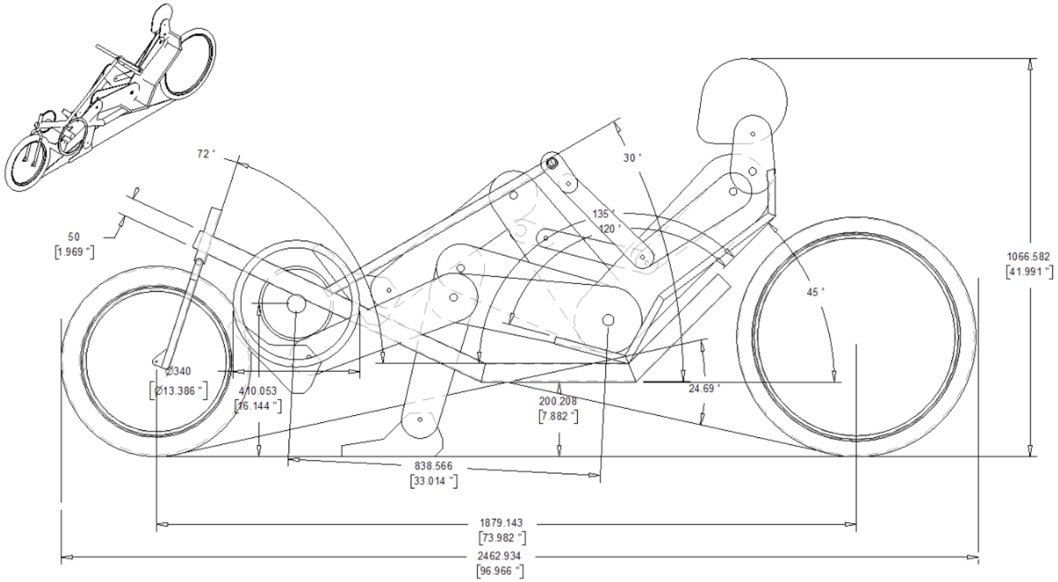
Human Factors

Ergonomic factors were considered to make the boat more user friendly. 5 percentile population was used calculate seat to treadle distance. 95 percentile population was used to calculate the seat dimensions. An ideal seat is characterised by the ideal alignment of the back ensuring comfortable seating position as well as a firm back support. The dimension of a recumbent bike was referred for the posture



Seam Height in (cm)	Pan Angle from Floor degrees	Back to Pan Angle degrees	Head Rest to Back Angle degrees
36 or more (91.4 or more)	15-30	100-165	130-170

Head Rest Travel along Back in (cm)	Seat and Head Rest Width in (cm)	Pan Length in (cm)	Height of Back in (cm)
7 (17.8)	18-20 (45.7-50.8)	12-24 (30.5-61.0)	16-24 (40.6-61.0) Adjustable



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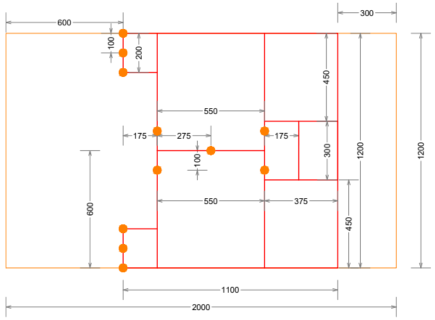
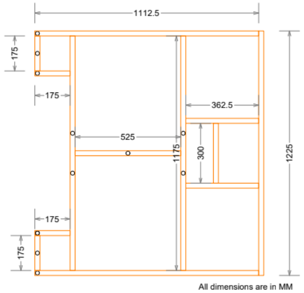
[dimension of the seat of a recumbent bike]



Frame Details



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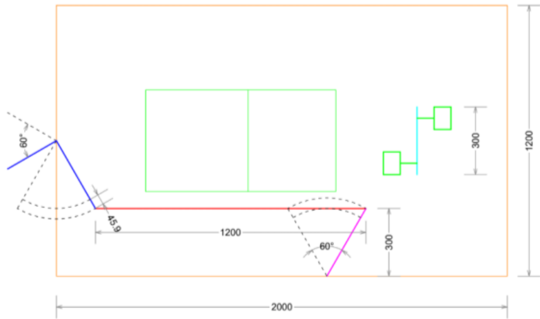
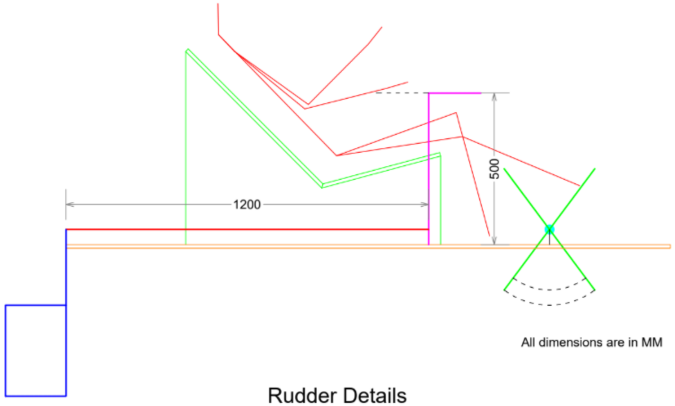


Rudder Details

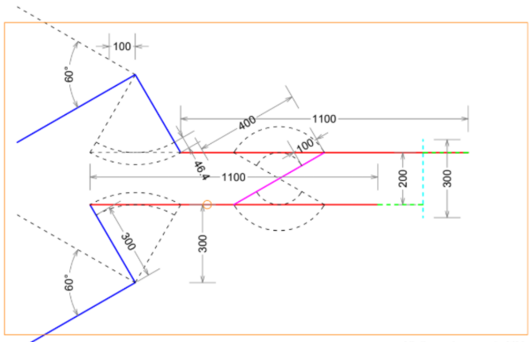


Rudder Details

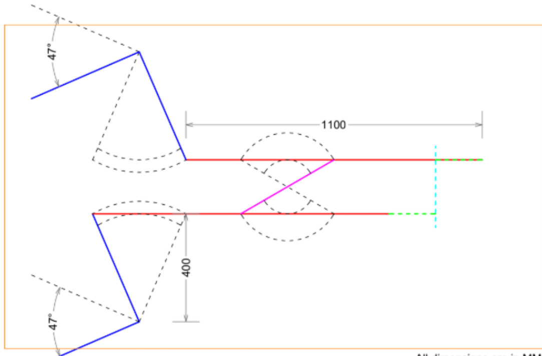
Variable factors

The variable factor which could be considered for future testing :

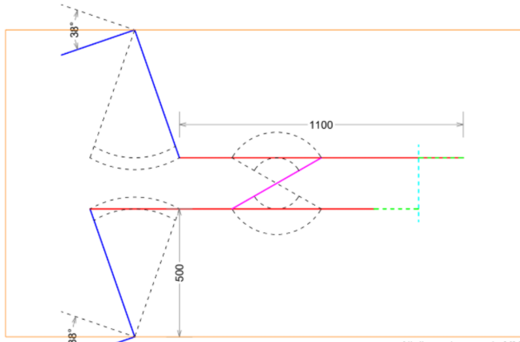
1. Variation of distance of the flap in relation to the boat
2. Variation of the fin size
3. Change in oscillatory angles



Mechanism Dimensions (θ = 60°) All dimensions are in MM



Mechanism Dimensions (θ = 47°) All dimensions are in MM



All dimensions are in MM
Mechanism Dimensions (θ = 38°)

The angle of oscillation can be changed with the position of the fin in three different places angle of 60, 47 and 30 can be achieved.

Fabrication





Conclusion

The rig was tested for the efficiency of mechanism i.e. the easy conversion of treadle motion to oscillatory motion.The force exerted by the treadle motion was easily getting converted without major loss of energy. The design can be optimised by adding more support and vertical bearings to make the motion smoother. Much less force is exerted as compared to peddling which makes this a better alternative to peddling boat.

Reference

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Annexure

Bill of Materials		
Linear Bearing - 10cm inner dia	5 Nos.	
Ball Bearing - 10cm inner dia	15 Nos.	
Fins	2 Nos.	0.3m X 0.4m
Rudder	1 No.	0.3m X 0.4m
Base - Marine Ply		2m X 1.2m
2" MS Flat Slots	7 Nos.	
Bright Bar - 10cm dia		6.5m (Running Length)
Framework - 1" MS Flat		10m (Running Length)
Pedals	2 Nos.	
*Nuts, Bolts & Washers as required		
*Additional Supports for Mechanism & Frame as required		