JEREMY SILVER-MAHR—SUPERVISOR(S): DR. REMUS TUTUNEA-FATAN, DR. EVGUENI BORDATCHEV

University of Western Ontario - Western Research

National Research Council NRC·CNRC Canada

Application of Tensile Testing Machine For Measurement of Skin Friction Coefficient

Machine setup and workflow development to validate test results

Introduction and Purpose

- Traditionally fluid drag associated with skin friction is conducted by the measurement of constrained fluid flow across a textured surface. This works well for easy-to-handle fluids such as water and oil, however it is less feasible for fluids such as liquid metals.
- A device that measures the drag force on a surface through a static fluid would allow for different fluid types and sample geometries to be tested.

Machine and Testing Apparatus

- The machine used in these experiments is a Chatillon CS2-225 test machine equipped with a CLC-250G load cell accurate to 0.05 gf (0.0005 N)
- Typically force testing machines are used to determine the strength or endurance of materials and products by recording force and displacement data in a controlled manner.
- Often this machine would be used in the cosmetics or food industry to ensure quality control of products.

Sample properties and Surface Treatment

- A 50 mm x 50 mm aluminum square was machined at NRC to have a negative fish scale pattern on its surface.
- The fish scale pattern consisted of overlapping repeating circular planes 3mm in diameter angled to achieve 0.14mm of depth.
- The aluminium was then used in a hot press to emboss the fish scale image into a 0.32 mm thick sheet of PMMA (Acrylic).

- Fish scale patterns have been shown to reduce friction drag by prolonging the onset of a turbulent flow. [1]
- A control sample of smooth PMMA was used as a baseline for the sample with the surface treatment.

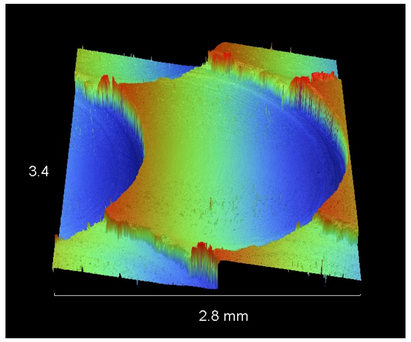

Figure 1: Topographical scan of single fish scale on the aluminum mold; taken with a WYKO NT1100 optical profilometer.

Testing Procedure

- In order to measure friction drag, each sample was lifted out of the fluid at a speed of 1200mm/min over 120mm of distance. During the test the sample remained submerged such that only the holding rod was elevated above the liquid surface.
- The experiment was repeated 10 times for both the control and textured sample, in both room temperature water and oil.

Figure 2: Testing Apparatus of non texted sample in oil

Results and Conclusion

	Water		Oil	
	Fish scale	No Texture	Fish scale	No Texture
Predicted Drag Force (gf)	N/A	0.0043	N/A	0.0411
Measured Drag force (gf)	0.0093	-0.0271	0.5316	0.6248

- The measured drag force values were calculated by averaging the 10 trials within the displacement range of 17mm to 117 mm such to negate irregularities associated with sample acceleration. The changing buoyancy force of the metal connecting rod in the fluid was considered as it was elevated out of the liquid during a given trial.
- The collected data does not show a significant difference in the drag force of the textured vs non textured sample.
- For measurements taken in water, the force values are below that of the known accuracy of the machine. Negative values indicate noise which exceeds applied loads.

Results and Conclusion

- It is evident that this testing apparatus is not well suited for drag force measurements with the current sample geometries and speeds. Samples tested in water have a measured and predicted value less than the known accuracy of the force sensor. While the samples tested in oil produced more meaningful data, the values are still too small relative to the load cell to draw meaningful conclusions. Going forward, a mechanism to increase the testing speed and increasing the sample size will facilitate higher force measurements yielding more meaningful results.

References

[1] Wu, L. and Wang, J., 2021. Study on the Drag Reduction Characteristics of the Surface Morphology of Paramisgurnus dabryanus Loach. *Coatings*, MDPI, 11(11), p.1357.