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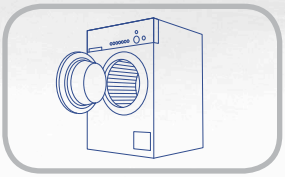
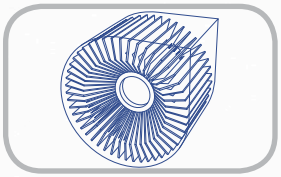
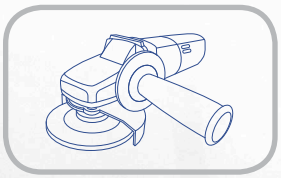
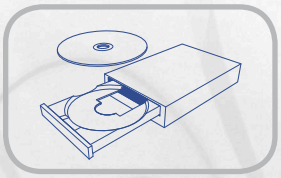

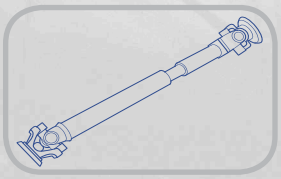
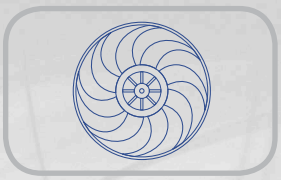
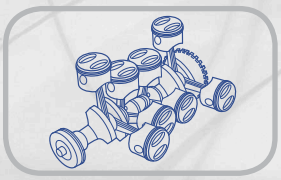
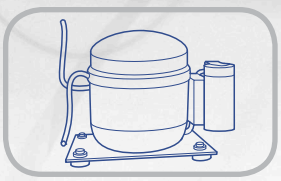
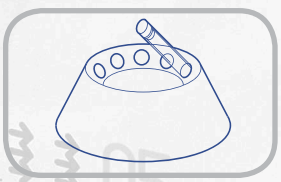

CURRENT STATE AND OPPORTUNITY

The XYO technology shows significant improvements in boat propeller performance during independent studies. Perpetual Industries wants to work with innovative manufacturers to optimize and implement the XYO balancer in their product.

Contact us to see how your product can beat the competition using XYO

XYO PROTOTYPE BALANCER AS APPLIED TO BOAT PROPELLERS

Summary Report

RESULT HIGHLIGHTS

The XYO technology reduces vibration by compensating for variable mass imbalance during the operation of boat propellers. Tests show that a **prototype XYO balancer** has a significant impact on the performance of a boat propeller. Some of the benefits of using XYO include:

- Reduce vibration for a smooth and efficient operation
- Lower fuel or battery consumption due to increased efficiency
- Increased life of the boat propeller and motor
- The ability to operate smoothly with a damaged propeller

Boat Propeller
Vibration Decreased by 47%

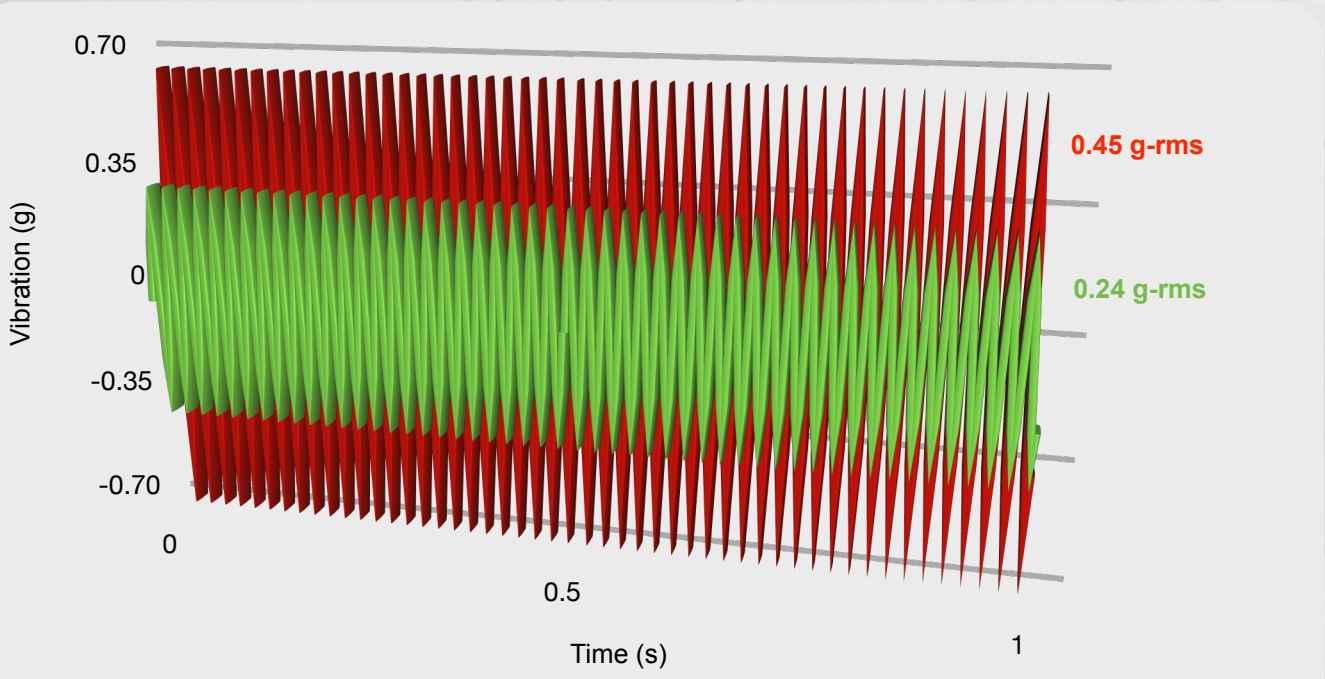

Figure 1. Impact of XYO on vibration of boat propellers

Note:

- **The results in this report are based on prototype XYO balancer. While the results shown are significantly positive, it is possible to exceed and improve upon these results with optimization.**
- **Perpetual Industries is looking for a capable partner that needs the competitive advantage that XYO can provide.**

INTRODUCTION

Propeller quality has a large impact on both the feel and mechanical reliability of marine applications. Mass imbalance has a large impact on the vibration level of a prop and hence the quality. During operation of a propeller, there are many ways for it to become unbalanced such as: cavitation damage, debris impact damage, and in the extreme case a broken or severely mangle blade. A severely damaged blade has the potential to damage the boat's drive train and damage other valuable equipment. Traditional balancing techniques are time consuming and do not maintain their balance over the life of the blade, and cannot protect from severe unforeseen damage.

XYO is a mechanical balancing technology that is able to compensate for variable mass imbalances. A propeller equipped with XYO is able to compensate for the residual imbalance out of production and the imbalance generated by damage to the blade occurring during normal use. XYO applies to all rotational machinery, but is perfectly suited to marine propeller applications.

TEST OBJECTIVE

The objective of the test was to determine the impact that an XYO system would have on the vibration of propellers (Figure 3). Specifically, the objectives of the test were to demonstrate:

- The vibration of a propeller with an XYO balancer would be less than that of a factory-balanced propeller
- The XYO technology could compensate for significant propeller damage, thus enabling the operator to "get back home" if such an event occurred

BALANCER PROTOTYPE

The XYO balancer (Figure 2) was designed to fit behind the propeller (Figure3) and has a smooth profile to limit flow obstruction. The balancer was designed to be threaded onto the propeller shaft and secured with a nut (Figure 5). The balancer was designed to compensate for 2,330g.mm of imbalance. This was based on the worst case of 21mm of blade loss from the tip of the blade. Figure 4 depicts this material loss.

Figure 2. Prototype XYO balancer

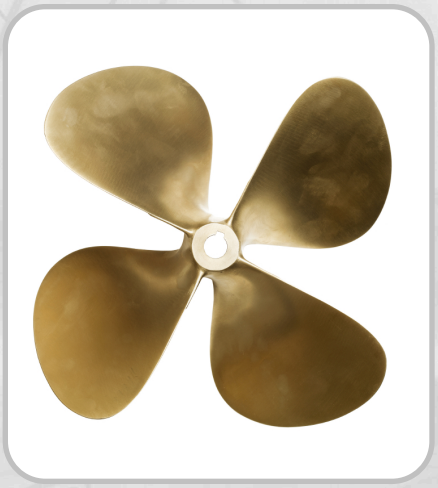

Figure 3. Sample propeller

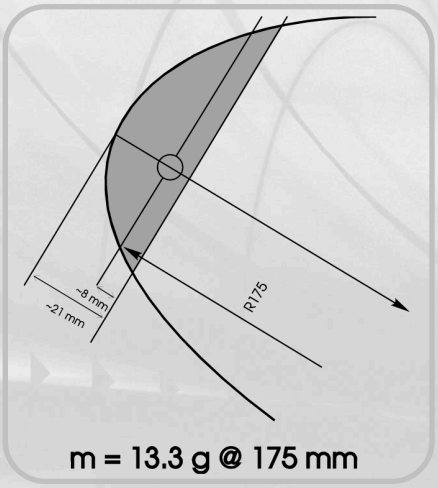

Figure 4. Damaged propeller for capacity estimation

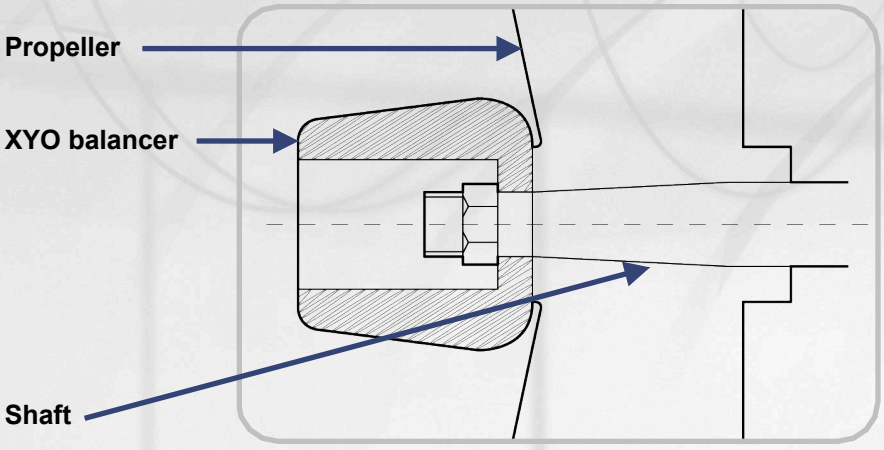

Figure 5. Balancer attachment to shaft

TEST OVERVIEW

Two types of testing were performed on the prototype balancer. They consisted of:

- A dry, out of water test
- A qualitative test during actual use of the boat

The dry out of water test was done to verify the performance of the XYO balancer before in water testing.

Boat

The boat selected for the test was a Ski Brendella Power Boat . The ski boat has had a PCM Marine 351 V8 inboard motor. The gear box to the propeller shaft had a 1.23:1 gear ratio. The speed ranges for typical use of the boat are as follows:

- Cruising speed at 3400 RPM
- Motor skiing speed between 2600 to 3400 RPM

Dry land testing

Dry land testing was performed with the boat out of the water with two 50g accelerometers attached to the steady bearing. The accelerometers were placed in the vertical and horizontal directions (Figure 8). A statically balanced propeller was used for the testing. The motor was accelerated from idle speed to 3000RPM.

Water testing

Water testing was qualitative in nature and no recording was performed. Three test configurations were initiated for testing. They were:

- Statically balanced propeller without XYO balancer
- Statically balanced propeller with XYO balancer
- Damaged propeller with XYO balancer

Firstly, a statically balanced propeller was installed on the boat and taken on the water to set the baseline. Then the XYO balancer was installed and retested on the water. Figure 6 shows the installed balancer behind the propeller. As an additional test the propeller was then damaged on all three blades to simulate the propeller hitting the bottom. A depiction of the damage to the propeller appears in Figure 7. The boat was then taken back on the water with the broken propeller and the XYO balancer.

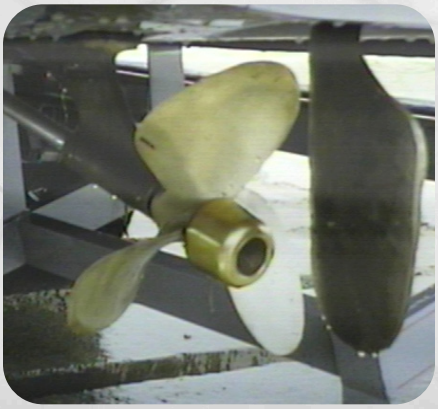

Figure 6. Balancer installed on boat

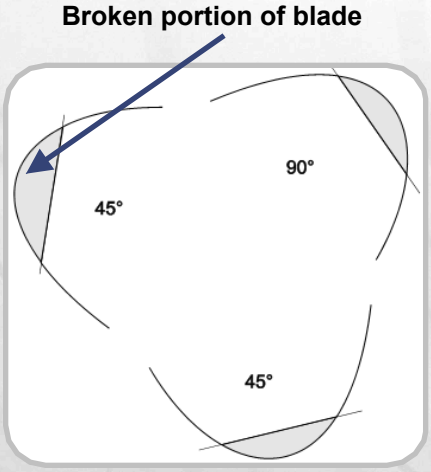

Figure 7. Damaged propeller for water testing

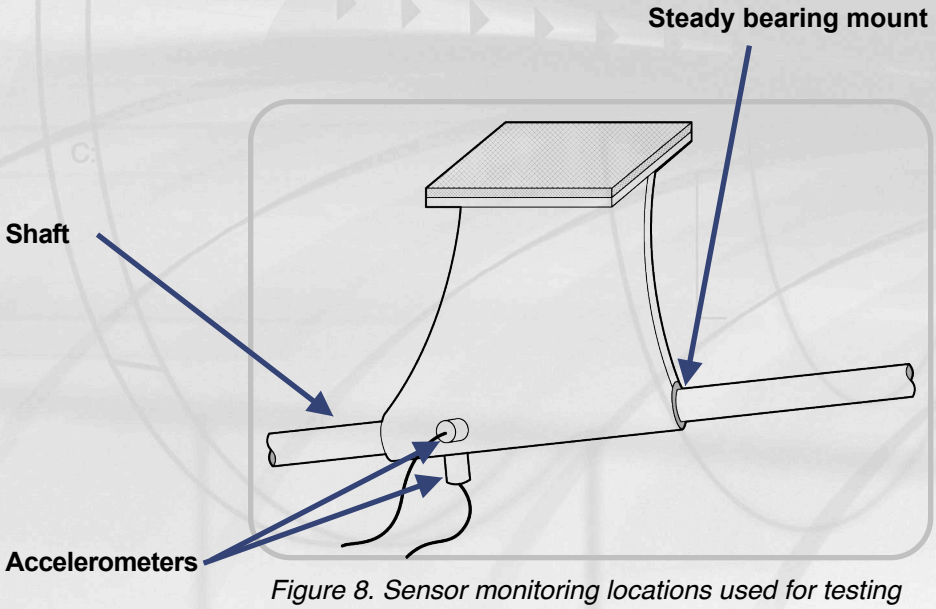

Figure 8. Sensor monitoring locations used for testing

TEST RESULTS

Dry-land testing

The results of the dry land testing appear in Figure 9 and are summarized in Table 1. Performance with the prototype XYO balancer is significantly better, by up to **47%.**

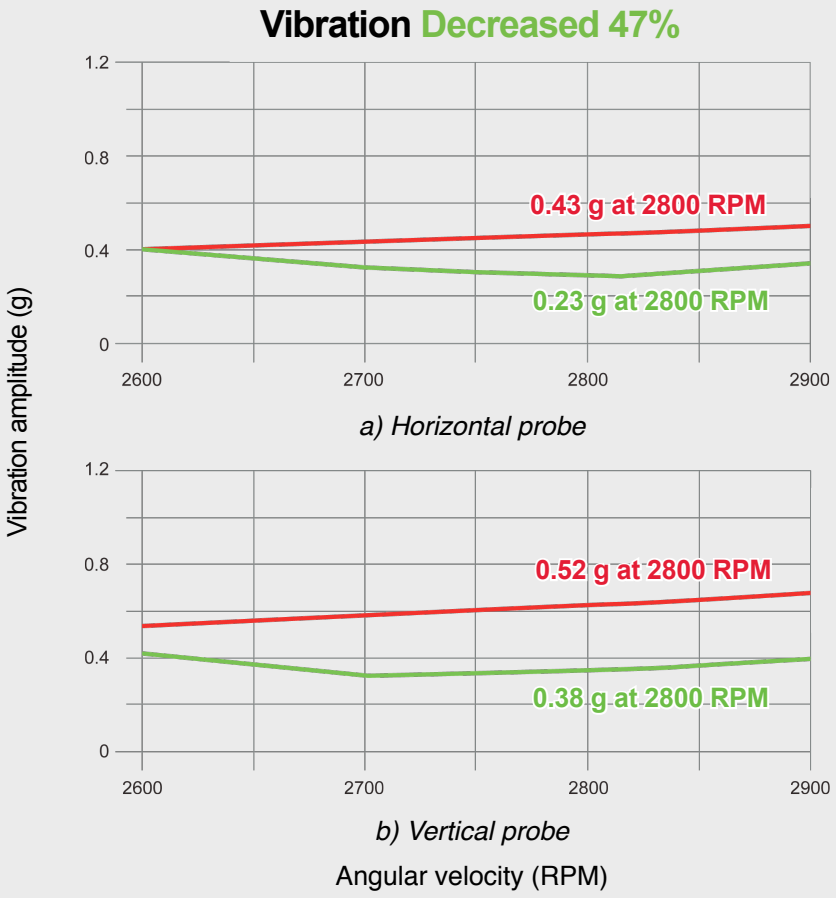

Figure 9. Propeller vibration with and without XYO Balancer

TEST RESULTS (Continued)

Table 1. Summary of vibration results for propellers running with and without XYO

RPM	VIBRATION (g-rms)					
	HORIZONTAL AXIS			VERTICAL AXIS		
	WITHOUT XYO	WITH XYO	REDUCTION	WITHOUT XYO	WITH XYO	REDUCTION
2600	0.40	0.40	0%	0.51	0.41	21%
2700	0.42	0.31	26%	0.57	0.34	41%
2800	0.45	0.24	47%	0.62	0.34	45%
2900	0.50	0.34	33%	0.63	0.40	37%

Water testing

When comparing the baseline test with the statically balanced propeller to the test with the XYO balancer, it was observed that:

- The top speed of the boat increased
- The ride was noticeably smoother at cruising speed

The major test of the XYO balancer's ability to compensate for random imbalance was in the **damaged configuration.** The damage induced on the propeller (Figure 7) was quite severe. Once this configuration was taken back on the water It was observed that even with such severe damage the boat was able to reach cruising speed **prototype XYO balancer** and there was **no noticeable vibration.**

FINDINGS AND CONCLUSIONS

XYO has been successfully implemented on a boat propeller system. XYO reduced residual vibration levels by **47%**. Also there was a noticeable improvement in vibration levels during real world testing. The continual balancing nature of XYO will have a great value over the life of the propeller. The reduction in vibration has additional benefits such as:

- XYO will protect the drive train and engine from severely damaged propellers
- The propeller life is extended by minimizing the effects of mechanical wear
- Propellers will operate smoothly and efficiently for increased performance
- Top speed of boat will increase
- Fuel consumption will decrease, extending range and cutting refueling costs
- Manufacturers can eliminate time balancing during production
- The propeller can operate smoothly with XYO even when it is damaged

XYO has a huge potential in this market. XYO can impact both manufactures and aftermarket consumers. **Manufacturers can lower costs** by reducing the time and energy to balance their propellers during production. The aftermarket consumer will gain the benefits of a superior ride quality, improved fuel consumption, and protection against severe propeller damage.

Perpetual Industries wants to work with a capable and innovative boat propeller manufacturer to optimize and implement the XYO technology and provide a strong competitive advantage in the market.

Impact of XYO:

- **Vibration reduced by 47%**
- **Top speed increases**
- **Power consumption decreases**
- **Propeller runs smoothly if damaged**