

Dyno Testing

What does it mean and is it relevant to our needs?

A dynamometer is a machine which allows us to test the engine under the conditions the engine encounters while in operation. We have no accurate way of determining the true engine output for our boat engines when installed in the boat. Boat speed is dependent on such a variety of factors such as hull shape and propeller efficiency, both of which make it difficult to get a true picture of the engine's individual performance. The boat's propeller is a fluid coupling which slips, making it difficult to obtain an accurate reading. The hull shape places a variable load on the engine depending on the speed. To eliminate these problems, a dynamometer is directly coupled to the engine which allows us to measure only the output of the engine under tightly controlled conditions in a test cell. To simplify the concept, think of the dynamometer as a generator or water pump, where the operator can vary the load to obtain a graph of the output at various RPM points.

Virtually all of our engines were originally tested and developed by their Original Equipment Manufacturer, OEM, using a dynamometer. Up until the 1970's dynamometers were quite complex and quite expensive, so their usage was confined to the OEMs. In the late 70's a relatively inexpensive high-speed dynamometer which utilized the PC and a simple absorber was developed

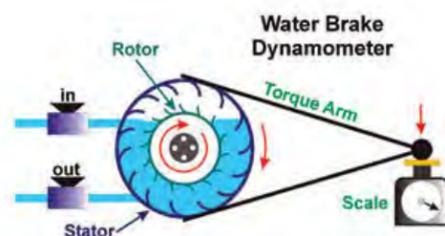


Fig. 1 A schematic of a water brake dynamometer

and marketed by the SuperFlow Corporation and aimed at the automotive racing and performance industry. It took the industry by storm and soon became the tool of choice for the racing industry. It allowed non-OEM companies to do complicated component testing and engine development as well as endurance testing. Soon, even small companies began obtaining their own or renting dynamometers at other shops. Today, for an engine shop not to have a dyno would be equivalent to having a hospital ER without a monitor to keep track of your vital signs. A dynamometer is a diagnostic tool and will only provide a measurement of the engine's performance data. Properly instrumented, the dyno will provide a myriad of data which will allow the operator to view the various attributes of the engine under controlled conditions. However, it is up to the operator to know what to do with the data in order to optimize the results.

Let's look at the data a dyno

provides. As we said earlier, the primary variable controls are RPM and load. By adjusting these we can simulate virtually any conceivable operating condition.

Load and throttle opening

Understanding engine load is critical to utilizing a dyno. We control the output of the engine by opening and closing the throttle to control the intake airflow, which when mixed with fuel burns to produce power. To illustrate let's assume you are towing your boat. You travel down a straight level road using 15% of the throttle opening to maintain your speed at 60 mph. When you reach the mountains, you must open the throttle to 40% in order to maintain 60 mph while climbing the grade. Your engine is still running at the same RPM but now with a much higher load. Because the power is greater, the fuel requirement will also be greater. Without a dynamometer it is impossible to accurately measure or simulate this fundamental performance difference.

For the sake of this story, let's assume we have just had our V8 engine rebuilt and want it to be dyno tested. Follow along as we outline the steps.

Prelude: The first step should take place prior to choosing an engine rebuilder. Find a shop which uses a dyno and understands the value



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Fig. 2 The engine is typically mounted on a separate mounting cart which allows it to be wheeled into the test cell where it is attached to the dynamometer prior to testing.

of dyno testing. Some of the small shops still firmly believe that dyno testing is unnecessary. They proudly point out that they have built 100's of engines and "never had a problem." Speaking as somebody who has been in the engine business for over 50 years, virtually every engine has at

least one problem. The task is to find and correct every problem before the customer takes delivery of the engine. It may be an intermittent oil leak or a cracked cylinder head, but you can bet that the customer will be plagued with it. Properly done, Dyno testing an engine is quality assurance which provides both the customer and the engine builder a level of confidence that the job has been done properly. The customer gets to see the engine perform under running conditions, with loads similar to what it sees in the boat. If there are any hiccups such as oil leaks, performance, or cooling issues, they can be addressed at that point where the engine is easily examined rather than having to get towed back to the dock and have the engine removed, just to fix an oil leak. The engine can be fine tuned to

optimize the output before it is ever installed in the boat.

Unless your engine shop is willing to provide you access to watch your engine being dyno tested, find a new engine shop.

Here's is typically how an engine dyno test session goes:

The engine is mounted to the dynamometer which is housed in a small soundproof room, much like a bank vault, called a dyno cell. Fresh air and fuel are supplied to the room as well as cool water to provide for the dyno and the engine cooling requirements.

- The operator sits outside of the cell at a control panel where he can adjust the various inputs and monitor the various outputs.

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Here's what he will control:

- Starter, Throttle opening, ignition, load, data recording
- Here's some of what will be displayed on the gauges: RPM, Load, Throttle opening, airflow, fuel flow, Pressures, spark timing, blowby, and temperatures.

The test session should begin with a minimum 2-hour break-in where the engine is gently run to ensure that nothing scuffs or wears during the critical initial startup. After starting the engine and setting the timing and verifying the overall operation, the load and RPM is gradually increased by steps until, after two hours, it is running under maximum load and RPM for the final segment. This will give the engine a chance to fully warm-up and seat the rings. If there are any leaks or inconsistencies, the engine should be shut down and the problem fixed before resuming testing. The fuel and spark timing should be conservative during this portion of the testing to avoid any problems.

Once the engine has successfully passed the break-in cycle, it should be re-examined. A compression test, leak down check, and valve lash check should be performed. The crankshaft end-play should be measured and the oil should be drained into a clean white bucket for inspection along with the filter, which should be removed and cut apart to look for any debris that would indicate dirt or unusual wear. If everything looks good, fresh oil and a new filter should be installed. Fire up the engine and set spark timing and fuel mixture for the best performance. Once this is done, the final power runs can be performed.

As part of the test, make sure that your engine is equipped with the exact parts which will be used in your boat.

For example, make sure you use your fuel pump and flame arrestor. Dyno facilities often have known good parts such as carburetors and distributors which they use to avoid problems. You want to make sure that all your



Fig.3. Dynamometers came in all sizes and with many features. The more expensive ones are electric and feature the ability to "motor" or turn the engine at speed without it running in order to measure the internal friction and pumping losses.

individual parts are tested in order to verify they are performing correctly.

Make sure your temperatures are good and that your oil pressure is at the recommended setting.

In the end, a dyno test protects both parties. The customer is assured that the work performed was done correctly, and when properly installed, the engine will perform as originally intended. If the boat fails to perform, the added value is that the customer can now virtually rule out the engine and look at the boat to find the problem. For example, the problem may lie in the original fuel tank, which over the years has accumulated debris now partially blocking the tank, fittings, and lines, or there may be a faulty electrical connection preventing the ignition from getting sufficient voltage to make a good spark. The rebuilder can rest on the fact that the engine left his facility having passed all the required tests. If the engine is improperly installed or is abused, he is off the hook since it passed a known set of performance standards. In short, the dyno test procedure keeps both parties honest. If your rebuilder flinches or does not feel a dyno test is necessary, find a new engine shop.

How does this concept fit into our world of antique and Classic Boating? Suffice it to say that in most cases if we are in the hobby long enough, we will encounter a restoration project which requires an engine rebuild or a desired performance upgrade. In most cases, the individuals and facilities which

provide our engine services **do not have dynamometers.** A dynamometer is not inexpensive, and for many of the smaller shops, it may be hard to justify the cost, but properly utilized it allows them to produce a superior product at a high level of confidence. In the end, a dyno will pay for itself.

In an earlier article in this series, we covered using a run-in stand to test your engine. For some, this is sufficient and it will uncover many faults, however not being able to run the engine under load will still leave many questions unanswered. **To better illustrate the difference, consider that a run-in stand is like an EKG test. It measures our heart function under relaxed conditions while a dyno test is like a stress test where the engine is run at peak loads while data is recorded.**

If you have your engine rebuilt, have it dyno tested so you have the assurance the work was done correctly and the engine will perform as specified. For many of us, we are at a point in our lives where losing the use of your boat for the length of time it takes to recognize a problem, remove the engine, find the fault, get back in line and arrange for the repair, and reinstall the engine easily outweighs the few extra dollars spent to have the job verified by dyno testing.

If you want to learn more, pick up a copy of a book called *Dyno Testing and Tuning*.

Happy Boating and best wishes to you in your rebuild project.