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The Superyacht

TRUTH • OPINION • KNOWLEDGE • IDEAS • AND EXPERT INDUSTRY ANALYSIS

REPORT

THE YACHT POLITICK
Justin Ratcliffe looks at the effects of politics – and politicking – on Italy's yachting industry.

RACE TO THE SUN
How the technology developed for Vripack's V20 – a solar racer – could be applied to the superyacht industry.

MEGA REFITS
Three of the world's top refit yards discuss their experiences refitting larger superyachts.

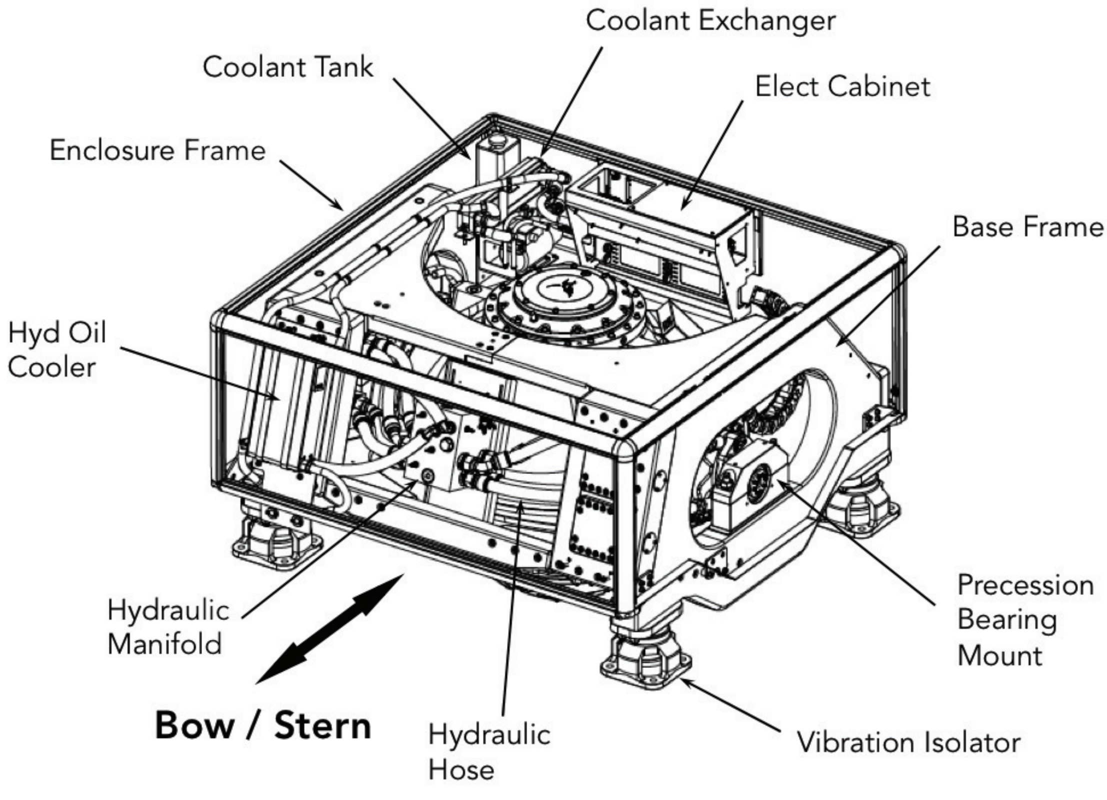
THE WINNING FORMULA
High-performance navigation technology and its impact on superyacht racing.

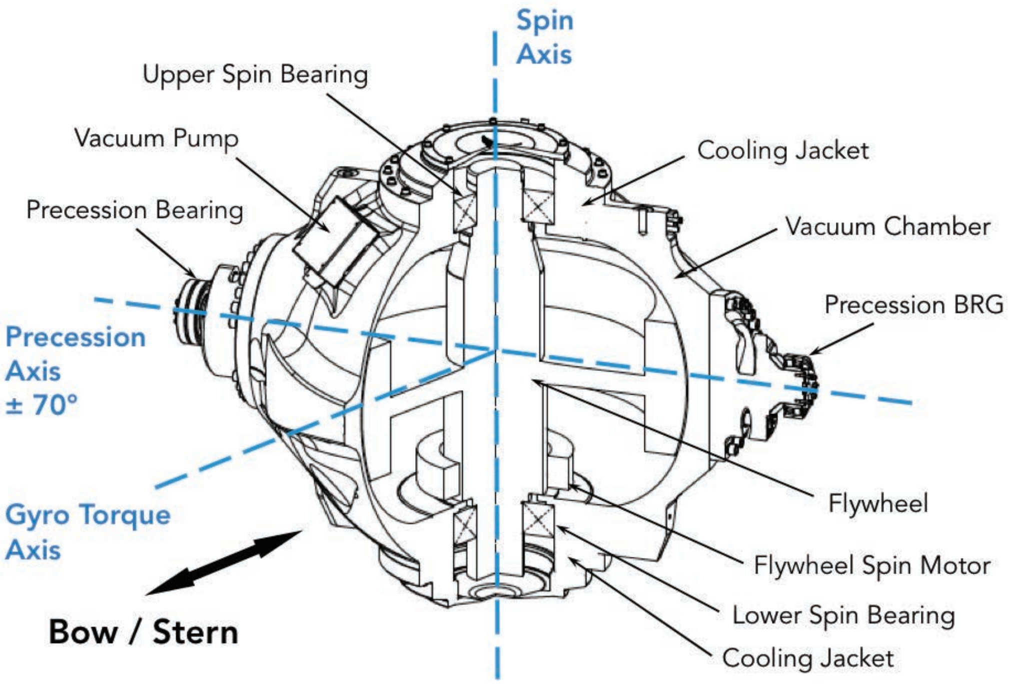
LIFTING THE LID ON GYROSTABILISERS

In the second of our stabilisation features **Paul Steinmann**, product manager of VEEM Gyro, outlines what a gyrostabiliser is, the variations between different gyrostabilisers, how they work, and the pros and cons of their use on board superyachts.

WHAT IS A MARINE GYROSTABILISER?

A marine gyrostabiliser is a device designed to reduce the rolling of boats and ships on waves. The device comprises a flywheel mounted in a gimbal frame allowing two of the three possible rotational degrees of freedom. This gimbal frame is then rigidly mounted to the hull of the vessel (for the purpose of this article I refer to a boat or motoryacht as a vessel), with the flywheel gimbaled within the frame. Most often the device is located in the engine room of the vessel.





DIFFERENCES BETWEEN GYROSTABILISERS

The key technical features that differentiate modern marine gyrostabiliser products are as follows:

Vertical vs Horizontal Spinning Axis

Theoretically both of these approaches produce effective stabilising torque; however, there are a couple of noteworthy differences. The main issue with a horizontal spinning axis is that it does not allow the use of natural precession. The resistance of the slewing-ring type bearings used is excessive, and requires the precession oscillation motion be driven to overcome this resistance.

Another limitation of a horizontal spin axis is that it is not convenient to provide the precession motion with an equilibrium point at zero precession angle. For vertical-spin-axis gyros, it is possible to arrange the precession bearing shafts so that the centre of gravity of the cage assembly holding the flywheel is lower than the shaft-line. This ensures that the precession angle always tends on average, towards vertical. This feature allows the advantages of natural precession to be utilised.

Natural vs Driven Precession

As described above, gyrostabiliser precession oscillation motion is a naturally occurring response. Utilising this naturally occurring precession motion means that the stabilising torque of the gyro is always perfectly synchronised with the vessel roll, regardless of how quick, slow or random the rolling motion may appear. This eliminates any inefficiencies caused by slow sensors, electrical or hydraulic systems and ensures timely response in all conditions.

> Gyros offer reduced drag and higher hull efficiency, and so, on most yacht installations, selecting a gyro over zero speed fins will result in higher speed, increased range and fuel savings.

For vessels with longer roll periods, the lower roll rate in small waves may result in less torque created to provide full precession oscillation range. This can create a band of rolling motion in which the gyro responds less vigorously than it could. On board, this may be seen as a lack of responsiveness in small waves. Driving the precession oscillation motion can eliminate

VEEM GYRO 260

this dead-band. This option may be advantageous for some megayachts, or larger commercial vessels. The downside is the additional power requirements, space and cost of the motive power unit. The driven precession oscillation option requires either PTO hydraulic pumps or a separate power pack.

Active vs Passive Precession Motion Control

Most modern gyros feature active precession control. This is a key technological advancement that gives modern gyros their high efficiency across a wide range of conditions.

In order to ensure optimal performance across a wide range of wave conditions without the need for user adjustments, the control system should also be adaptive. Adaptive control systems automatically search for optimal control settings without needing to be tuned by an operator. When executed well, this means the system is both simple to use, and also continually optimised.

HOW GYRO-STABILISING TORQUE IS CREATED

There are three intertwined parts to the process of creating gyro-stabilising torque. Note that each of these things occurs simultaneously, but it is helpful to consider each of them separately. Once the flywheel is spinning, the following process leads to the development of a stabilising torque that opposes rolling motion:

1. Waves cause the vessel to roll.
2. Rolling motion combines with the spinning flywheel to create precession oscillation motion.
3. Precession oscillation motion combines with the spinning flywheel to create stabilising torque.

The physics that causes these intertwined actions is called gyro-dynamics. If the flywheel spins in the opposite direction, the induced precession motion will be in the opposite direction, but the stabilising torque will be identical.

Finding space to install the gyro(s) is a key decision point when considering them. If the hydraulic power packs and possible watertight compartments around fins is considered, then the space requirement differences may be negligible.

FACTORY TESTING REPORT

From November 2014 to February 2015, VEEM carried out an extensive series of successful factory tests on the VEEM Gyro 120 model (VG120). The factory test rig is a containerised dynamometer with a large concrete base to stabilise the rig under the high torque loads created by the gyro. The gyro is bolted to the dynamometer and the flywheel is forced to precess (rock back and forth in what would be the forward/aft axis of the yacht). By forcing the flywheel to precess, maximum stabilising torques are generated and recorded by the dynamometer.

The dynamometer is a steel frame supported by load cells, which allows the loads and torques generated by the gyro to be measured and recorded. These tests verifed the VG120 model's capacity to generate stabilising torques up to an impressive 120kNm.

The controlled environment created by the test rig allowed VEEM engineering staff to drive the gyro at its maximum capacity and verify that the gyros mounting structure behaved as designed, that designed heat balances resulted in the expected running tempertaures of bearings and hydraulics, and that vibration levels were extremely low. The test rig will also provide our customers with the option of witnessing factory testing of their equipment prior to delivery.

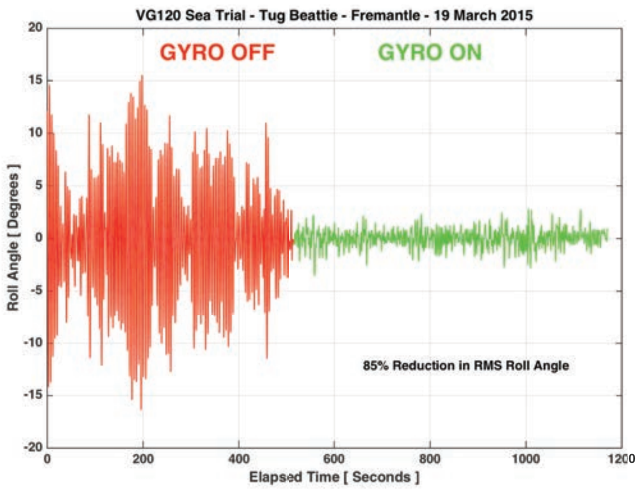
SEA TRIALS REPORT

Following successful factory testing, a VG120 unit was mounted on the aft deck of a local Fremantle harbour tugboat to allow at-sea testing of the unit. The tug, *Beattie*, is a steel hulled towing tug. While smaller than a superyacht application for the VG120, her steel structure and flat hull means that she rolls in a similar manner to a much larger yacht.

On sea trials day, 19 March 2015, a new swell came in from the SW and added to the wind driven waves. At around 10:00am, when the stabilising tests were carried out, the wave environment comprised an 11.5-second period swell at 0.9m significant wave-height, combined with a 4.2 second period wind-sea at 0.75m significant wave-height. The natural rolling period of the tug is 4.8 seconds.

The tug was set up to drift in beam seas. Rolling motion was recorded with the gyro locked in 'Standby' mode, and then the unit was set 'Active', which freed the flywheel to oscillate back and forth in the centreline axis of the tug (precess). The crew of the tug will attest to the dramatic change in motions. With the VG120 actively damping motion, the deck remained practically level, where it had been rolling vigorously seconds earlier.

The strip chart of rolling angles over time (below) clearly illustrates the effectiveness of the gyro in reducing rolling motion. The percentage reduction in RMS roll angle was recorded as 85 per cent.



HOW GYRO-DYNAMICS WORKS TO MAKE A GYROSTABILISER

Firstly, waves cause the ship to roll about its roll axis. Because the spinning flywheel is effectively locked into the ship's roll axis by the precession bearing mounts, the flywheel also rolls about this axis. This rolling rate on the spinning flywheel creates a torque at 90 degrees to the roll axis; that is, on the ship's pitching axis (bow to stern). This is also the gyro's precession axis.

Then, because we have allowed the flywheel to rotate in the ship's pitching axis (gyros precession axis), the applied torque results in oscillating rotational rate about the precession axis. (Note here that the roll rate of the vessel directly determines the rate of precession – the two are directly linked.)

Now that the flywheel is rotating about the precession axis, the gyro-dynamics create a torque at 90 degrees to the precession axis. This happens to be the ship's rolling axis. Very conveniently for us, the torque created by the combination of the flywheel's angular momentum and the precession rate is in exactly the opposite direction to the rolling motion of the vessel. So, we have a device that naturally wants to oppose the wave-induced rolling motion of the vessel.

If we did not allow the flywheel to rotate in the ships pitching axis (that is to precess), then there would be no stabilising effect at all. This is how we turn the gyro off at sea when we don't want stabilisation. We simply lock the precession axis to prevent the flywheel from rocking in the ship's pitching axis and the generation of stabilising torque stops instantly. In reverse, when we want to turn the gyro on, we simply unlock the precession axis to allow the flywheel to start rocking backwards and forwards again. The stabilising torque immediately begins to be generated again as soon as the vessel rolls, following the steps described above.

COMFORT AND MAINTENANCE OF GYRO STABILISATION

Gyros offer reduced drag and higher hull efficiency, and so, on most yacht installations, selecting a gyro over zero speed fins will result in higher speed, increased range and fuel savings. The low (less efficient) aspect ratio and higher area of zero speed fins compared to traditional fins accentuates the overall efficiency gains available with gyros. They also provide a higher quality of comfort because, as a gyro's roll stabilising torque is created by the rolling motion itself, there is absolutely no time delay, or lag between the wave induced rolling motion and the stabilising torque produced by a natural precession gyrostabiliser. The result is an amazingly smooth application of the massive stabilising torques produced.

> There is no need to run cables and piping through frame penetrations with gyros as the gyro is delivered as a fully self-contained item, which saves time, effort and money coordinating frame penetrations, cable runs and piping runs through the hull.

Gyros alone cannot control steady list; they are great at opposing motion, but when the motion stops, they stop creating torque. This means that steady list angles induced during turning manoeuvres, or caused by side winds, cannot be corrected by a gyro acting alone. Fortunately there is a highly efficient solution to this:

In order to optimise trim (to maximise fuel efficiency, and speed) and to manage list angles, it is recommended in many cases that the gyro be installed with either transom flaps or interceptors. By doing so, you get all of the comfort and low drag benefits of the gyro (including no appendages prone to damage and fouling), as well as steady state trim and list control. Trim flaps and interceptors are extremely efficient at controlling steady state running trim and list. Both solutions also maintain clean hull lines free of appendages and their costs.

It is true that if two pairs of fins are installed, they can provide some trim control, but doing this detracts directly from their capability to reduce roll and is not an efficient way to control trim from a drag perspective.

In terms of internal space, if a fin system uses PTO hydraulics or an electric drive then internal space requirements will be less for fins than for a gyro solution. As engine room space is becoming more and more compressed in order to maximise owners' spaces on modern yachts, this is becoming more important. Finding space to install the gyro(s) is a key decision point when considering them. If the hydraulic power packs and possible watertight compartments around fins is considered, then the space requirement differences may be negligible.

In addition, there is no risk of grounding, damage or fouling with gyros as they are located within the hull, unlike stablising fins, which can be damaged in collision or get tangled with nets and cables. The gyro's location inside the engine room also means that there is a reduced noise level compared with fins (especially at night) and there is no requirement for technical personnel to enter the owner's spaces for the operational or maintenance tasks required by fins.

Finally, the actual installation of the opposing applications is marginally different. The gyro requires no dry-docking for maintenance or installation, unlike fins where there could be requirements to remove large components for factory servicing. There is also no need to run cables and piping through frame penetrations with gyros as the gyro is delivered as a fully self-contained item, which saves time, effort and money coordinating frame penetrations, cable runs and piping runs through the hull.

CONCLUSION

While the sea trials reported here were carried out on a commercial tug boat, the fundamental capability of the VEEM Gyro to apply gyro dynamic torque to a rolling hull in order to virtually eliminate roll motions has been confirmed. Noise and vibration levels have been confirmed to be low. The power demand of the VG120 has now been verified at 12kVa.

Software enhancements developed as a result of these trials are currently being implemented, and these will produce even more impressive results during further trials planned in late March. ■

TO COMMENT ON THIS ARTICLE,
EMAIL: *TSR161@SUPERYACHTREPORT.COM*
WITH SUBJECT: LIFTING THE LID ON GYROSTABILISERS