Controlled Vapour Dampening for exceptional rough water performance

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Every type of vessel has its strengths and weaknesses with power catamarans no exception. For catamarans, slamming under the wingdeck when driving into head seas has always been considered their archilles heel. Sometimes inadequate clearance or volume of the tunnel in the initial design causes the slamming - more often than not it is heavier building weight or greater loading than originally intended that make the clearance less than ideal. Unfortunately this can be a vicious circle, as the slamming loads experienced by an overweight boat require more strength to prevent damage which then adds more weight.

In some cases it is a lack of reserve buoyancy or overloading in the bows that will cause the vessel to pitch more than it should and therefore drive the wingdeck down into the waves creating slamming. On some very fine bowed power catamarans I have heard of people being thrown up so violently by wingdeck slamming, that they hit their head on the ceiling. This is obviously an extreme case of lack of reserve buoyancy in combination with low bridge deck clearance; however it does illustrate the forces that can be generated.

Tunnel volume is also critical in allowing the water to dissipate either before or after it strikes the wingdeck, therefore narrower catamarans require a higher wingdeck clearance than wider ones. Planing power catamarans will create aerodynamic lift at higher speeds, which softens the ride, however when conditions cause them to come off the plane they are vulnerable to heavy slamming, particularly as many of them have very little or no wingdeck clearance at rest.

Displaning or high-speed displacement power catamarans do create some lift from the wingdeck starting around 15 knots. When designing this type of power cat it is usually considered more important to reduce slamming by raising the wingdeck rather than lower it to create lift, as they are looking for sea keeping across a range of speeds. Whilst the noise and dramatically increased structural loads are the obvious effects of wingdeck clearance and tunnel volume, there are also a less obvious effects that slow the vessel and decreases fuel efficiency.

The first of these comes from a wave created off the inside of the hulls, which meets in the middle of the wingdeck and hits the underside near the transom. This causes drag by increasing the wetted surface and sometimes a kick in the stern from a small slam. This drag slows the vessel or loads the engines further, increasing fuel consumption. This can be caused by either the hulls shape or by too narrow a beam which makes the pressure waves created by the bow sections to meet early and under the wingdeck rather than aft of the boat. (Fig 1)

The second effect is felt in a following sea when the wingdeck is pressed down by the buoyancy of the stern and the forward momentum of the vessel. The vessel will literally surf or run on the wingdeck, which has a benefit in that it decreases the chance of broaching or burying the bows by the lift it creates. Unfortunately it has the disadvantage of increasing the wetted surface dramatically and therefore slowing the vessel, making it more vulnerable to a second wave pooping it. It also increases fuel consumption as more power is needed to overcome the wetted surface.

The third and probably least recognised effect is jets or squirts of water driving up at an angle from the inside of the hulls and hitting the fwd wingdeck panels about a third out from the centre line. (Fig 2) Whilst these do not add to the wetted surface dramatically, they are very noisy and if they strike in a less supported area of the wingdeck can be damaging as the force is very localised.

Most power catamaran designers have been well aware of these problems and there have been a number of different approaches tried to solving them.

1/ **The first and obvious solution is to make the wingdeck clearance greater.**

Most designers are constantly working on this issue, unfortunately like all design features there is a balance in the wingdeck clearance that is practical for each size of vessel. If the wingdeck clearance is higher than is balanced, it will either start to look silly, reduce the accommodation to a ridiculous point or the vessel ends up with too much windage, and is difficult to manage in a cross wind. Raising the wingdeck will reduce the lift created at over 15 knots however I believe that the small trade off in top speed is balanced by the ability to maintain a high cruising speed in rough conditions.

2/ **The second approach has been to start the wingdeck further aft.**

This is a design feature that has been carried over from sailing catamarans that I believe defines the difference in philosophy between a converted sailing cat and a true power catamaran. Most power catamaran designers using the high-speed displacement or displaning type hull form have moved across from designing sailing catamarans. It is understandable that they will use features they are familiar with, like the look of, and understand. I believe however there is point at around 15 knots where sailing catamarans and power catamarans separate in their evolution in the same way as did monohull powerboats when they developed distinct paths of displacement and planing types. Whilst the mathematical distinction is much harder to define in power catamarans between displacement and planing, the requirements for sea-keeping are not.

Higher bows with their increased windage will have a detrimental effect on the windward ability of a sailing cat as the windage pushes the bows to leeward. This however is not a problem with power cats as they have no requirement to work to windward and their power to weight ratio is constant. High bows increase reserve buoyancy and create a drier deck.

Raked bows reduce the waterline length of a sailing cat and therefore decrease the hull beam to length ratio for a given overall length. Whilst it is always advantageous to maintain as high a hull beam to length ratio as possible, it is less critical in a power cat where the power is constant and lift can be created, reducing resistance and wetted surface. Raked bows on a power cat provide a better distribution of reserve buoyancy lifting the wingdeck over waves and therefore reducing slamming. (Fig 3)

Sailing cats will have their bows depressed by the drive of the sails particularly the leeward bow, therefore keeping the wingdeck entrance further aft makes more sense as the sails often drive the wingdeck down on to the water. Power cats over 15 knots have the opposite affect, with lift created by both the hull sections and by air being funnelled through the tunnel. If the wingdeck entry starts further aft on a power catamaran, it will often make the wingdecks entry angle considerably steeper. (Fig 4) This will lead to a more severe slam when it does occur and a far more dramatic slowing of the vessel as not only is the wetted surface increased, but the vessel will also be required to climb over the wave rather than slide over it. Other disadvantages to starting the wingdeck further aft on a power cat are reduced torsional rigidity and increased wetness as the spray off the bows is compressed between the hulls and blown up between them on to the deck. (Fig 5) This spray can be so strong that it can blow the trampolines out at higher speeds besides making the fore deck a very wet place to be.

3/ **The third area solution has been to place a V-pod or nacelle in between the hulls to increase the reserve buoyancy and to break up the solid water, therefore reducing slamming**.

These V-pods or nacelles started as either enlarged stringers (Fig 6) or almost a wide shallow third hull. (Fig 7) The smaller stringer types break up the water reasonably well and stiffen the panels, however they do not provide much reserve buoyancy. The wide shallow type were not much good for anything as they just filled the tunnel volume up and provide more flat panels to slam on.

In the last few years the design of these V-pods has been influenced by the wave piercer style, with either a deep third hull type under the fwd sections and/or radiused arches further aft. Whilst these go some way to breaking the water up and increasing reserve buoyancy, they often negate the benefits by funnelling the water tighter into the now two smaller tunnels and increasing its velocity when it finally hits the wingdeck panels. (Fig 8) Because the surface area inside the tunnel has now been increased when water is compressed, the wetted surface will rise even further, slowing the vessel and increasing the power required to maintain speed. If the wingdeck to inside topside is too radiused without a V-pod, narrow power cats sometimes exhibit rolling characteristics more like a monohull. (Fig 9)

Wave piercers have been recognised as better boats at punching into a sea than catamarans as their large nacelle provided reserve buoyancy. Unfortunately, because of the lack of reserve buoyancy in their small outer bows, they have always had a strange corkscrew motion in a quarter following sea and therefore an inclination to suffer wave slap on the outer sections of the nacelle, which can be both noisy and damaging.

How can we further improve power catamaran wingdeck design?

The difficult part of trying to improve the design of the inside topside's and wingdeck is that it is very difficult to observe what is happening, particularly at sea. Whilst simulations and tank testing are useful design aids, this is one area of boat design where I believe practical experience and real time observation is far more effective. The greatest advantage of being both a boatbuilder and designer is that I personally carry out sea trials allowing me to experience the boats performance and handling first hand. Once I decided that improving this area of power catamarans was my next challenge, I began to study what was happening under the wingdeck and understand why.

I was able to gain a unique perspective during a trip on "Negril" when I was able to observe through the inside bathroom portholes where the water was being driven and its effects when punching into large seas at speed. It would have been too dangerous to try and see through the tunnel from either the bow or the stern in these conditions or to get close enough to observe from another vessel. I had suspected for some time that the slamming under the wingdeck of power cats was different to sailing cats.

I had been able to feel sharp localised "hits" in the fwd sections of the wingdeck when feeling around inside cupboards and under berths when at sea, however, I could not see where it was coming from. On "Negril I could see both where it was coming from and where it was hitting. We made small modifications to "Negril" based on what I had observed which had immediate benefits to her ride and performance. To this visual research, we were also able to correlate the increase in fuel used on the fuel flow meters as "Negril" slid over solid water with other clients reports on the slowing effect they had noticed in following seas when surfing on the forward wingdeck sections.

From this research and development, I set about redesigning the inner topside's and wingdeck shape to improve the power catamarans performance in three areas.

(A) Improve their the rough water ride,
(B) To minimise the potential for structural damage caused by slamming loads,
(C) To increase fuel efficiency by minimising wetted surfaces and therefore drag in all conditions.

The solution

I had been working towards the solution for a number of years by using small stepped V-pods and asymmetric topside's to reduce the panel sizes in the wingdeck plus chines to create lift and turn down the water. This led me to look at further ways to "break the water up" and to research the lubricating properties of vapour (a mixture of fluid and air) as apposed to the increased drag created by solid water. As displaning vessels are not going fast enough to utilise pure airlift as would a tunnel hull or hydroplane, I had to look at different solutions.

Over the past 32 years of boatbuilding and design I have studied stepped planing hulls, seaplane float design and many different ideas to lubricate hulls with air to reduce resistance and wetted surface.

Naval archaeologists and historians now believe one of the reasons the Vikings were so successful in their surprise raids was the speed they achieved in their longboats from the air induced to the hull by the clinker or lapstrake construction. Through tank and full sized hull testing they have now been able to substantiate this theory of air lubrication.

Australian sailing dinghy designers experimented with inducing air from the cockpit to under the hull in the 1960's - to my knowledge it was quickly banned indicating its success.

Powerboat designers have occasionally used induced air, aft of the propellers to release a hull that would not plane. Powerboats have always achieved higher speeds in slightly choppy water and many different types of racing powerboats use athwartships steps to induce air under the bottom reducing drag.

Float planes used steps on their floats to induce air and their pilots crossed their own wake to get even more air under their floats when taking off loaded, in flat water. It was obvious from this research that air and water mixed was far more slippery than the surface tension of pure water - the next part was to work out how to create the vapour and a small amount of lift at the same time.

Planing strakes have been used extensively to generate lift on V-bottom planing hulls and to soften their ride. There have been many instances of deep V-hulls that would not plane when loaded, which were transformed by the addition of bottom strakes or wide, flat chine strakes. The next logical step was to combine the use of steps and lifting strakes on the wingdeck, inside topside's and nacelle to create the lubricating and lift effects I was looking for. (Fig 10)

In redesigning these areas I found other benefits including stiffer and smaller panels, plus I was able to increase the vessels interior volume and torsional rigidity. The fore and aft chines created lift by turning the water down and into spray. They also allowed me to increase the buoyancy when and where I wanted it, by varying their width and position. Their entry angle provided additional lift in following seas preventing the bow from burying and the wingdeck driving down onto a wave. The V pods or nacelles can now be discontinuous and positioned to best deflect solid water and strengthen the wingdeck. The nacelles themselves have chines to increase reserve buoyancy, provide lift and reduce the wetted surface in solid water. In a following sea, the multiple chines induce air and therefore reduce the wetted surface and drag, increasing fuel efficiency. When all these features are combined in the correct positions and volumes, we have Controlled Vapour Dampening or CVD.

CVD is not just a pod or chine of indiscriminate shape added to an existing design, it is a carefully researched combination of features and volumes. As it is all above the waterline, it will not have any effect in calm water except increasing the internal volume of the boat and providing better structural engineering. CVD's real benefit will be realised in the vessels ability to maintain high cruising speeds and a quieter smoother ride in rough conditions. CVD will reduce slamming and therefore structural loads and the lubricating effects of the vapour will increase fuel efficiency.

I was able to observe the effects of the first stage of CVD on the latest Leopard 1270 when powering into seas. As the boat came down out of a wave, the chines created both a lifting effect and they squirted water across the tunnel creating a vapour mix which could be heard “snorting” or “sneezing” as it compressed. The effect was very like the progressive dampening of a shock absorber, with the hulls volumes working like the spring and the compression effect working like the oil, gas or air mixture. Even the first stage of CVD has lifted the already high level of ride comfort to another level with the full package to be fitted to new Leopard 1270 M series and all new designs.

My design office is currently working on programs to computer simulate the effects of CVD on each new design and we are developing a range of its features that could be retro fitted to any of my existing designs. I believe that the ability to control and dampen the ride of power catamarans is going to have a profound effect on their development and marketability. Their lifestyle advantages are well known, enhancing their ability to maintain high cruising speeds in rough conditions on top of their fuel efficiency and range. This may well be just the break through that cements their position in the mainstream power-boating market.

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