The HamiltonJet HJ212 & High Revving Engines

We have noticed a lot of discussion recently around the issue of the HJ212 waterjet and how to set it up to get maximum engine power out of modern high rpm engines. We think there is a bit of confusion and misinformation being spread around this complicated issue, so here we'll try to clarify some of the relevant factors and explain why HamiltonJet do things the way we do them.

Factor 1 – the HJ212 is quite a large jet for small NZ jet boats. It was developed to best suit the larger and heavier jet boats common in North America. However, what we have found over many years of experience is that the HJ212 can be very effective in NZ river boating conditions, provided its characteristics are well understood and used in the right situation to get its full benefits.

Factor 2 – Larger jets are more efficient than small jets as they will develop greater thrust for the same power input. The down side is they must spin slower than smaller diameter pumps to avoid the problems of cavitation, which is primarily caused by high impeller blade tip speed (and influenced by boat speed). In other words the tip of each blade on a large jet impeller will travel faster through the water than a small jet turning at the same rpm.

Factor 3 – To reduce impeller rpm and avoid cavitation we use a higher rated, or coarser pitched, impeller. This will reduce the rpm of the engine without losing thrust from the jet unit. In larger waterjet applications they will often use a reduction gearbox to maintain engine rpm but slow the speed of the jet's mainshaft to accommodate a coarser impeller.

Factor 4 – Engine Power and rpm cannot be taken in isolation. These are not the only factors that should be applied when setting up a waterjet. You should also look at risk of cavitation and slippage, what happens when you load the boat or get aeration from a blocked intake, and of course how you like to use your boat (ie: for skiing, racing, trolling etc).

Factor 5 – there is no perfect waterjet for every boating situation. Different jet designs and diameters will have advantages and disadvantages over others, and no one jet design will work perfectly in every boat with every driver. What jet boaters must first do is work out what they want from their boat then select the jet and engine to achieve this.

The truth is the HJ212 will never perfectly match some modern high revving engines to allow the engine to achieve full revs and power. Because it is quite a large jet compared to most others in the NZ jetboating industry, it is simply not designed to spin at such high speeds.

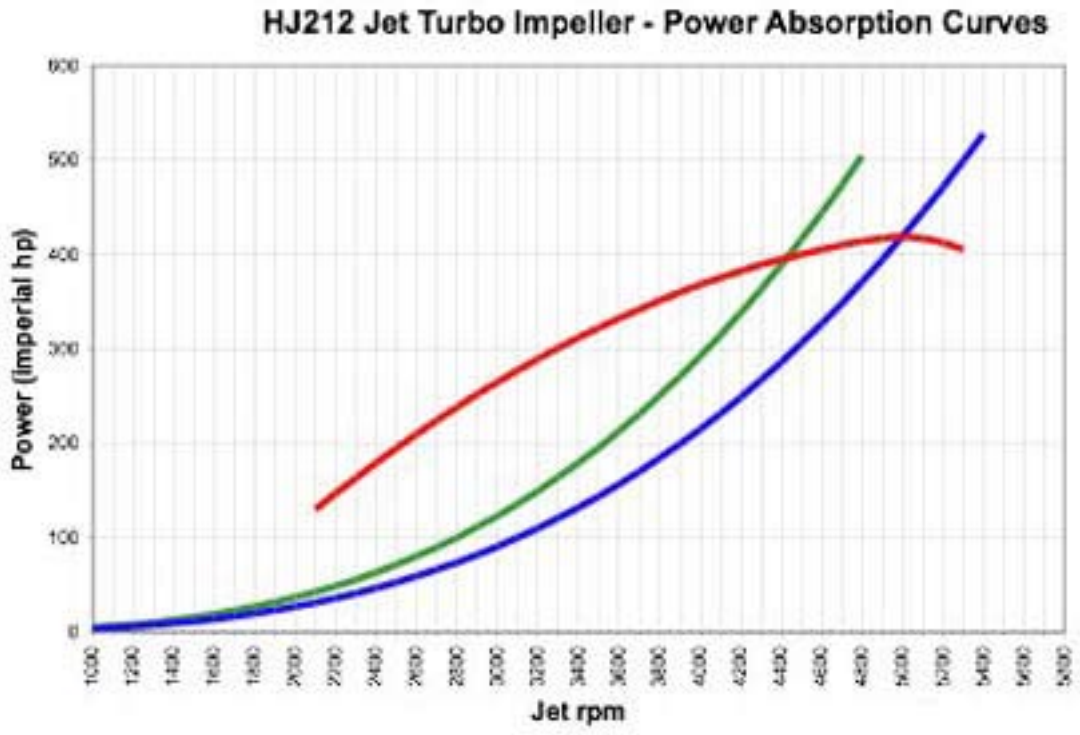
But don't be mislead by what some other waterjet manufacturers might tell you – this is not necessarily a bad thing or a failing of the HJ212. It is simply a characteristic of a larger jet and can be used to your advantage.

To understand why the HJ212 might still be your best waterjet option, you first need to understand engine and jet power curves and be able to weed out the facts from the fictions.

Engine Power Curves

In all honesty, these don't really mean a lot to jet boaters. The picture below shows what a typical engine power curve looks like (red line). Engine power curves are all slightly different, but the important thing to understand is that as you near the point of peak power the curve is quite flat. This means that reducing rpm around this point, even by quite a large amount, results in only a small loss of total available power.

The engine power curve represents the MAXIMUM POWER THE ENGINE IS CAPABLE OF AT ANY PARTICULAR RPM. The engine will run happily anywhere below this line. Yes, at full available power the engine will be working a bit harder if rpm is reduced, but this only occurs at the power curve limit and is far less severe than trying to drive your car up a hill in top gear!



Waterjet Power/rpm Curves

Regardless of what the engine power curve looks like, the waterjet will determine the rpm at any given power input. The green line on the graph below shows a coarse pitch impeller (high kW rating), and the blue line is a finer pitch (lower kW rating). Where these lines cross the red engine power curve shows the rpm and power you'll get at WOT.

As you can see finer pitch impeller is a perfect match to the maximum engine power, with it crossing exactly at the peak of the engine power curve. The coarser impeller is going to operate at a lower rpm right through the power range, so will cross the engine power curve slightly back from the peak and as a consequence there will be a slight decrease in hp available at WOT.

Both impeller options are a perfect match to the engine. Right through the power range the engine is operating within its perfomance parameters and is not being overloaded (ie: not at peak power for the given rpm). The only difference is at WOT, when the engine is in a loaded state. And in this situation the difference is about 25hp and 600rpm.

The coarser pitch impeller will overload the engine slightly at WOT, unless the engine management system has reduced the power output to avoid this. Many modern fuel injected engines can be so controlled to reduce emissions.

The real question is what happens when you are not at WOT? – and the fact is most jet boaters won't spend much time at full throttle anyway. Drop a mere 200rpm on the finer impeller and you are now well within the comfortable range of the coarser impeller, but you are turning 500rpm faster.

Impeller Pitch

A common perception is that you need to pitch your impeller exactly to get maximum hp and rpm out of your engine, or you will not be getting the best from your propulsion package. This is true to a degree, but this must be weighed against the many performance benefits you will get by using a larger waterjet, turning slower, such as cavitation resistance, economy and load carrying capability.

With a HJ212 and its coarser impeller compared to smaller jets, you will get a number of benefits…

- Higher efficiency
- Less risk of cavitation "breakaway" when getting onto the plane
- Better load carrying capability
- Reduced cruising fuel consumption
- Better performance in aerated water
- Less noise and vibration
- More comfortable cruising operation
- Ability to absorb rpm increases as the impeller wears or intake gets blocked
- Less engine wear (if not operated at WOT)

Yes, you will lose some top end power and consequently a small amount of speed, but if you want to tow a skier, cruise up a river with all the family and a picnic lunch on board, or be able to keep going with a grill full of stones, then that little bit less power at WOT is a small price to pay.

To really make full use of that extra bit of power at the top end you will need a smaller jet diameter, a light boat and be driving fast a lot of the time.

Don't forget that no engine is designed or built to operate at full rpm for long periods of time, so if you drive like this you'll end up spending more on maintenance and your engine and jet won't last as long. The majority of your recreational family boating will be at a cruise speed, and in that situation a coarser impeller and slower turning jet is going to make for a much more pleasurable boating experience – less noise, less vibration, lower fuel consumption etc.

Ask yourself why most modern cars have an overdrive gear? It is to reduce engine rpm when cruising to make for a quieter, more enjoyable drive, and save on the gas bill. Would you want the same for your boat?

It is important to note that you should avoid overpitching, as your engine can feel a bit sluggish. But if you seek the right advice and expertise in setting up your impellers, then this shouldn't be a problem.

The Intake Design Limitation

One of the main driving factors behind the desire to get maximum power and rpm from the engine is to get more speed out of the boat.

However, it is important to understand that intake design becomes a potential limiting factor at high speed, so you may not get any speed benefit from that extra engine power that comes with higher rpm. The intakes on most recreational jet units will lose performance at around 60 knots, so the boat will struggle to go faster than this regardless of how much more power you put in – so that power is wasted.

Others may claim their intakes are designed for higher speed performance, which may be true, but the downside of this is poor intake performance at slower speeds and when the boat is heavily laden. Unfortunately it is a trade-off – you can't really have the best of both worlds.

So What Jet Unit is Best?

As I said earlier – there is no perfect jet that is best for every situation. The simple answer is to pick the waterjet to suit the type of boating you like to do.

If you are a recreational boater wanting to get a few people up the river at a good efficient cruise speed, do a bit of trolling, tow a few skiers etc, then the HJ212 is the ideal choice.

If you are a speed merchant wanting to go as fast as possible as much as possible and eek every little bit of power you can get out of your engine, then you should select a jet unit and impeller which will closely match the engine's maximum performance limits.

HamiltonJet's Position

We don't believe it is relevant to compare different waterjet designs on only one performance criteria – in this case achieving maximum engine power. Smaller diameter waterjets will naturally spin faster so may look better in tandem with high rpm engines, but there is simply much more to it than that.

Currently HamiltonJet has three different turbo impeller options for the HJ212, which can be trimmed or pitched to create intermediate rating options down to about 2kW. This range will directly match many engines producing maximum power up to over 5000rpm.

We recognise that there is probably a need for a finer turbo impeller to provide an option for a closer match with the HJ212 and high revving engines in certain applications, and we are investigating this in relation to impeller efficiency and other performance factors.

However, even if there is an exact impeller match available we will advocate setting up your HJ212 impeller on the coarse side and pulling back your maximum revs a bit. Our experience is that the many advantages of a coarser impeller outweigh the small gain you might get in speed.

But don't take our word for it – try some different set up options and decide for yourself. We can set up the jet to match your preference and get the best from the engine and waterjet package.

To give you an example, we recently fitted a Chev LS3 engine driving a HJ212 in a HamiltonJet 141 hull. On testing we found the jet was slipping when accelerating with a 2.4kW Turbo impeller pulling about 5000rpm. So we trimmed down a 3.4kW Turbo impeller to rate at about 3kW. The engine now tops out at 4700rpm but gives a solid kick on take off and purrs along at cruise speed. She plains comfortably at about 2400rpm and the customer is very pleased with its performance.

At the other end of the scale we have our new 151 demo boat with an LS3 turning a pitched up 2.4kW turbo impeller at around 5200rpm WOT. She planes nicely at 2600 and tops out at over 105kph.

Neither of these boats are set up to achieve maximum engine rpm and power available, because the larger size of the HJ212 simply won't allow it. But because the jet is more efficient than small models it produced higher thrust for the same power input, so they are not losing much in terms of top end speed and gaining a lot elsewhere.

With the set up these boats are running now you can load them up with passengers, suck a few stones into the grill – whatever you do to them they will still perform, and save you on fuel while doing it! That is the difference using a HJ212 with its larger and coarser impeller makes!

Conclusion

Well, we hope this helps clarify some of the issues involved in matching waterjets with engines, and the options available to you. Impeller pitching and engine power / rpm is a complex issue and can be confusing with all the contradictory information and opinion out there – so don't believe everything you read or hear.

You will have to work out what is best for you and how you want to use your jet boat, then talk to the various waterjet manufacturers about how they can best help you achieve this.

So, if you have any questions about it, particularly with regards to the HJ212 or older HamiltonJet waterjet models, don't hesitate to phone or call into the factory to discuss this matter further with our experts. We have been doing this for a long time and have a lot of experience getting the best match of impeller to engine.

We can also assist you with any of your impeller rebuild or pitching requirements.

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