Selection and test of replacement Autoprop propeller for Fisher 34.

Arctic Blue is a 1991 Fisher 34 fitted with the original Volvo MD22 engine driving a fixed three blade 20x10 inch propeller via a 2.4:1 gearbox. The boat was extensively refurbished mechanically in 2014 including a complete engine rebuild, and had only 200 hrs use when I bought her in Greece in the spring of 2017. Having taken advantage of her location for a quick holiday in the sun, we then sailed / motored her back to Plymouth in the autumn of 2017 via the French canals.

Arctic Blue sailing in Plymouth Sound

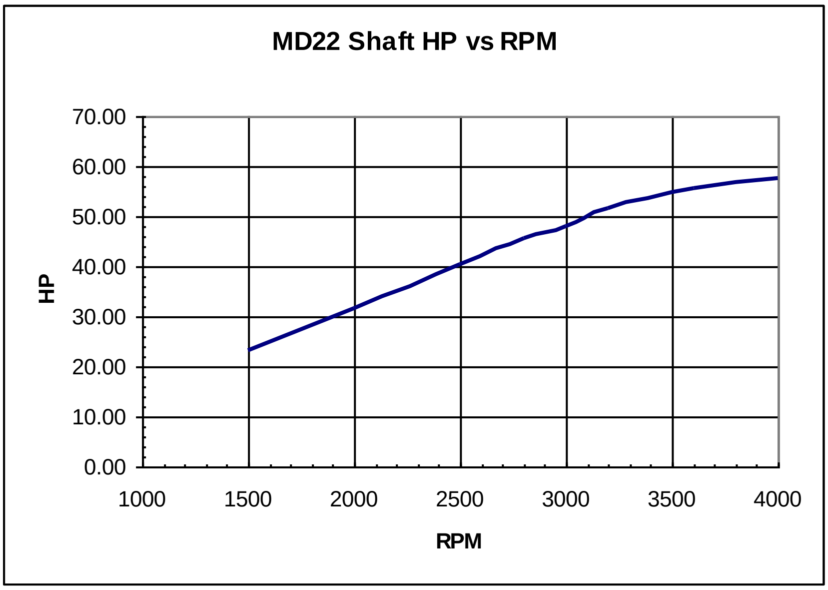
During this light wind trip, it soon became apparent that in cruising mode (1800-2000 rpm), the boat was slow, struggling to maintain 5 knots even in calm conditions. Higher speeds up to 7+ knots could be achieved but at significantly increased revs and engine noise, making such a long trip, (or any trip for that matter), very unpleasant. In over 35 years of keelboat sailing on five previous boats, including a 7 year circumnavigation, I've always been able to motor comfortably at about 6 knots in the 1800 - 2000 rpm range. So why could a beautiful Fisher 34, fitted with a 59HP engine, branded a “motor sailor”, not provide an equivalent performance?

As a retired engineer with a sad interest in these sorts of questions, I decided to investigate the issue with a view to sorting it out. What follows is a brief summary of my analysis and solution.

The starting point was to review the propeller selection. The MD22 is rated 59HP at 4000 rpm, and the original propeller would have been sized using 90-100% of maximum engine power and revs. I knew the original prop had been replaced with a larger 20x11 three blade, but that the previous owners had it re-pitched to 20x10, presumably because he felt it was limiting engine performance. This is borne out by the fact that the 20x10 limits the engine to 3200 rpm. This fact is not in itself a problem, but it does mean that the maximum power available is reduced from 59HP to 52HP as seen from Fig 1.

My initial thought was to increase the pitch again to improve lower rev performance, but I was concerned that doing so would simply revert to the original problem and/or make little difference at cruising rpm. So to help understand the issue I decided to conduct a series of propeller design calculations using the Bp-delta method from the Propeller Handbook by Dave Gerr. The results of this are summarised in Fig 2.

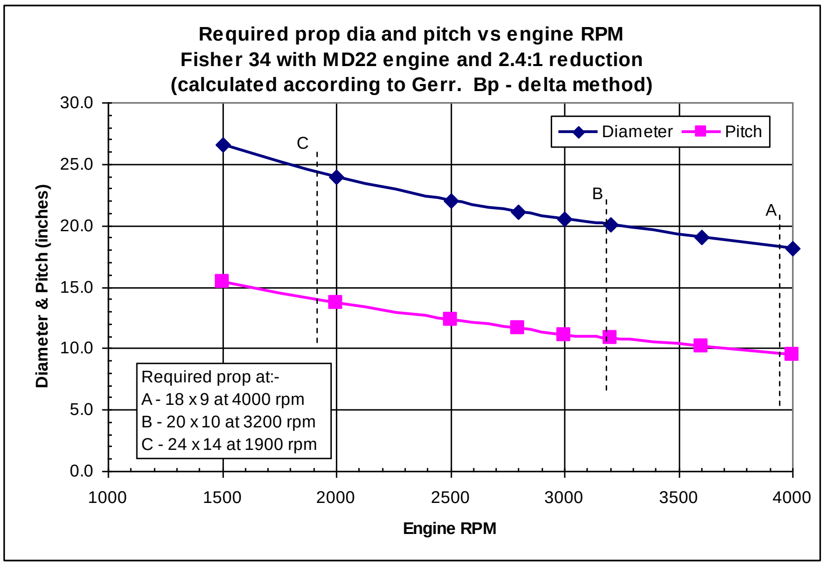
Fig 1



The results show that the original prop design at 4000 rpm would likely have been an 18x9. It also confirms that the modified 20x10 prop was a good compromise corresponding with the 3200 rpm limit actually experienced. This suggests that a minor change back to 20x11 for example would offer negligible improvement and any further increase in pitch would likely limit power without much low rev speed gain. At cruising speed of 1900 rpm the required prop is a significantly different animal at 24x14. However it would be impractical as it would severely limit power to round 30HP – Fig 1.

The results illustrate the large difference in propeller specs needed to achieve efficient propulsion over the full rpm range and the inevitable compromise imposed by a “one size fits all”, fixed prop installation. The gap between maximum rpm and cruising rpm is particularly acute for higher revving engines like the MD22 particularly on a heavy displacement boat that ideally wants a low revving engine with a large course pitched prop.

Fig 2



There are basically three potential solutions to this dilemma.

1) Accept the fact that the engine needs to be run at higher rpm to achieve improved speed.

2) Install a new low revving engine to reduce the design/cruising gap and fit a larger prop to take advantage of the lower revving engine.

3) Install a self pitching propeller. (SPP)

Based on Fisher Owners forum discussions and other input from testimonials, Bruntons Autoprop quickly established itself as a strong candidate. It has to be said, that there were also some negative comments and scepticism about the Autoprop, however my engineering sense was that much of this was speculation or likely related to other root cause problems.

The insight provided by Fig 2 strongly supports the need for a propeller which would automatically vary its pitch at different rpm's. One of my data points reinforcing this, was experience with a three bladed folding Gori prop with "overdrive" function fitted on my previous boat. The pitch on this could be changed from fine to course by use of throttle and gear shift, and was highly effective at reducing rpm in cruising mode. However this prop is essentially a two position option and is not self pitching over the full operational range. There are also various other mostly feathering props, where the pitch can be adjusted and fixed, however after fixing, they perform like a fixed prop.

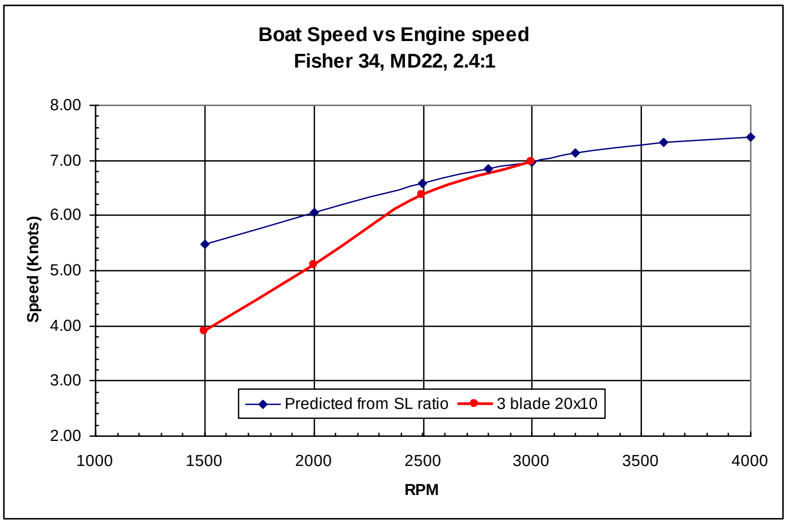
The basic concept of the Autoprop (see www.bruntonspropellers.com/autoprop) is that centrifugal force acting to open the blades, is balanced by the hydrodynamic force on the blades in such a way that the blade pitch automatically adjusts to the optimum position to give maximum thrust. While the concept makes sense, the detailed mechanics and hydrodynamics were not at all obvious to me and I was initially unsuccessful in finding a detailed technical paper on the subject (see note 1). I was however reassured when Bruntons said they could guarantee an extra knot of speed at lower rpm, or a reduction in revs of 300 – 400rpm for the same speed. Couple these with the obvious sailing advantages gained from the proven 85% reduction in prop drag relative to a fixed prop and the case for the Autoprop seemed strong.

Before committing myself, I thought it would be interesting to try and test whether Bruntons claims were reasonable by comparing actual performance of the 20x10 against the boats best theoretical performance with the MD22 engine.

As part of the previous calcs I had made an estimate of the theoretical performance using the MD22 power curve in Fig 1. This Speed–Length (SL) ratio method considers waterline length, displacement and shaft power. The calculation does not involve any propeller details, but effectively assumes the boat is fitted with a series of best efficiency propellers capable of extracting the shaft power available at a particular rpm. The result is illustrated in Fig 3 as the curve labelled "Predicted from SL ratio" and can be contrasted to the actual measured performance of the 20x10 propeller. The latter was measured during 2019 as the average of two or three runs in opposite directions.

Fig 3 shows that at lower rpm, the boat is significantly underperforming relative to the potential indicated by the SL curve, but at higher rpm actual performance converges with the theoretical, but is limited to 3200rpm. The result highlights a significant mismatch between the power available from the engine, and its translation into thrust by the propeller. The inefficiency of the fixed prop at lower rpm suggests that there is indeed significant scope for an SPP to close the gap. In particular the results suggest a full knot of speed could potentially be gained at cruising rpm, or indeed the 400 rpm shift quoted by Bruntons is a realistic possibility.

Fig 3



On the strength of this analysis, and after some discussion via Brunton's agent, an H6 504 Autoprop was selected. (H6 refers to the hub detail, H6 being a heavier and stiffer construction than H5, and the 504 is the nominal diameter in mm. i.e. 20"). In my spec to them I made it clear that I was seeking to primarily achieve improved cruising speed, and that I was happy to accept an over prop design limiting engine speed to around 3200 rpm.

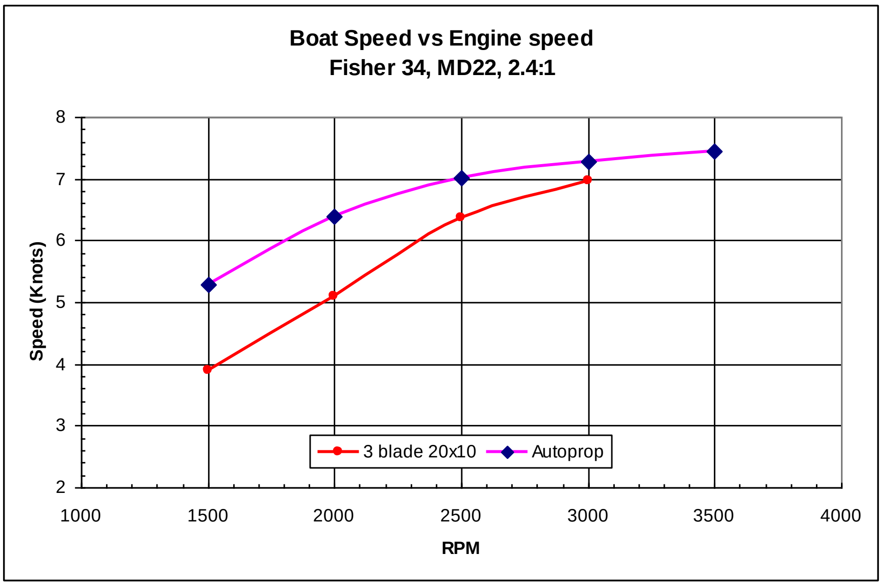
It's worth noting, that while the generic size e.g. H6 504 is a catalogue standard, the pitch on each Autoprop is uniquely set for the target power and rpm, then tested in a tank before delivery. In my case, Bruntons set the pitch to achieve 3200 – 3500rpm.The implication being that on another Fisher 34 with a different engine and gearbox, the pitch may be different.

New Autoprop and Cutlass bearing

So how did it perform?

The results of sea trials under engine are compared to the previous fixed prop and shown in Fig 4. A lot of data was collected and averaged over multiple runs in opposite directions in reasonably calm conditions.

Fig 4



The performance improvement is nothing less than outstanding and has exceeded my expectations. In particular:

Low rev performance has improved by 25 – 35% at 2000 & 1500 rpm respectively. Cruising speed is greatly improved with 6 knots being achieved at 1800 rpm and just under 6.4 knots at 2000 rpm.

Maximum speed is 7.4 knots at 3500 rpm. The fact that the engine can run up to 3500rpm means that more power is available than with the fixed prop. i.e. 55HP vs 52 HP. It's interesting to note that the SL calc predicted a displacement speed of 7.4 knots at an SL ratio of 1.38 but at 4000 rpm i.e.59HP.

Maximum engine speed is 3500 rpm, corresponding to the upper target set by Bruntons. At this point the engine becomes overloaded and starts to emit black smoke as would be expected. In practice I would limit the maximum operating envelope to around 3000 rpm.

Performance is better than predicted by the SL calculation over most of the operating range, implying the Autoprop has excellent efficiency.

The installation is absolutely quiet and vibration free. I should add that the shaft is slightly oversize at 35mm though the taper is a standard Admiralty 1:12 corresponding to the original 1-1/4" shaft. The heavier shaft will marginally improve system stiffness. I also have a Volvo seal which eliminates any lateral vibration being transmitted to the hull and the cutlass bearing is new.

With respect to Bruntons 400 rpm claim, the results show that the difference is more like 500 to 600 rpm. This may be unique to the boat/engine combination and because we started with such a big difference in required prop specs across the speed range, and may not be typical of all installations. However the Brunton expectation was exceeded.

Further trials are necessary to establish performance in more challenging wind and seas and to further understand the maximum rpm limit. I've managed limited sailing so far, but the little I have done indicates a significant improvement in both speed and pointing ability. Sailing and motor sailing performance need more assessment, but the benefits of the Autoprop under these conditions are pretty obvious. I have not noticed any improvement in acceleration from a standing start, which is hardly surprising when the prop will be at it's finest pitch during this condition. I have also not noticed any significant difference in prop walk or very slow speed manoeuvrability ahead or astern, but these were never important considerations for me.

In conclusion I am delighted with the Autoprop as it has met and exceeded all my expectations, and has certainly put a capital M back into the Fishers' Motor sailing pedigree.

Matt Findlay

Fisher 34, Arctic Blue.

Note 1: Subsequent to taking delivery of the prop, David Sheppard at Bruntons provided me with a technical paper "The Technical and Commercial Development of Self-Pitching Propellers", presented in 1992 at a meeting of the Royal Institute of Naval Architects. The paper covers the operating theory, development of the design methodology and it's subsequent verification by tank testing in collaboration with Southampton University's Wolfson Unit. I was much impressed and reassured by the science and engineering behind the Autoprop, as well as its unique performance characteristics compared to fixed blade types.