POPULAR flying

Magazine of the Popular Flying Association

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JANUARY/FEBRUARY 2002

Wilksch WAM 120 Diesel Update – *It's Looking Good!*

OSHKOSH 2001

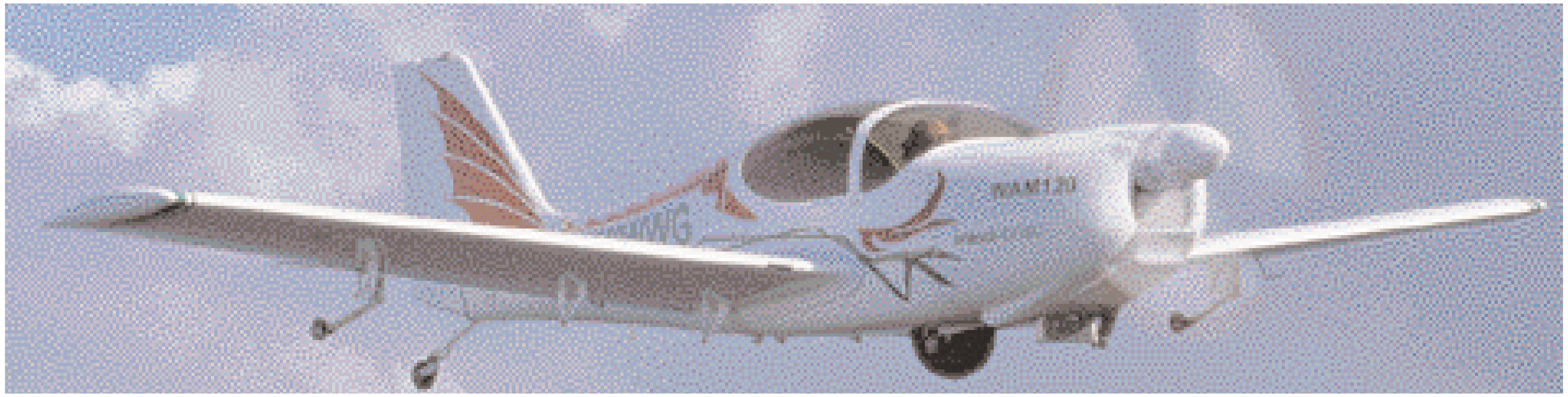
Steve Stride s Cranfield winning Corby Starlet

Jihlava delights

Three novice tourists head off to the Czech Republic

The Wilksch WAM-120

Aero Diesel Engine – An update



Nigel Hitchman visited Wilksch Air Motive and reports on the progress of this exciting new engine.
Ed Hicks took the stunning air-to-air shots of the test bed Europa.

With the cost of fuel getting higher and higher, anything that will bring the cost of aircraft operation down is welcome and the Wilksch WAM-120 Diesel aero engine will do just that in dramatic fashion. Burning agricultural diesel or Jet A-1, both available for less than half the price of Avgas, and with an expected fuel consumption of around 15 litres per hour for the 120hp engine, we ll be able to have a lot more fun for our money! £10 per hour direct operating costs have been estimated. The purchase price, currently £10,000, also compares favourably with other new aero engines of similar power.

In the March/Apr 2001 Popular Flying, we learned about the recent flight tests in a Europa carried out by John Brownlow at Bicester in January. Further tests with improved prototype engines have taken place during this year, leading to another series of development flights in October. A technical overview of the engine can be found in July/Aug 2000 Popular Flying.

The engine has already proved itself capable of providing 130hp on the test bench, with more to come. It has also completed the 50-hour endurance test required for certification at a 100hp rating, although the engine will not actually be certified for the time being. Development is ongoing to improve the efficiency, further prove the reliability and reduce the weight of the engine.
The target production engine weight of 100kg and 120hp rating is expected to
be achieved for the 3 cylinder engine.

The simplicity of the engine must be another great selling point, both in terms of pilot engine management tasks and reliability. With the primer, ignition switches, mixture control, EGT gauge and carb heat all removed from the cockpit, the pilot only has a power lever to operate and oil/coolant temperatures to worry about. Also unlike most aero engines, there is no need to wait for the engine to warm up or worry about shock cooling during descent, you just start up and run it like you would your car. There is also considerably less plumbing required than on a Rotax.

Design

Wilksch do not manufacture the engine themselves, they do the design and development, marketing and assemble and test all of the engines. Most of the manufacturing is carried out by local industries, mostly involved with the Formula One or sports car industry, together with the use of some off the shelf automotive parts where these are already the optimum specification. Although the design started on the traditional drawing board, it is all now on a CAD/CAM machine. This greatly speeds up the design process, particularly modifications, and of course gives an output that can be directly programmed into the machinery making the parts, with the required accuracy and repeatability and far less chance of human error.

The in house test cell is able to run the engines on a computer controlled rig, with environmental control to simulate different running environments and cooling efficiencies. With over 100 parameters available this tells the designers exactly what is happening. A second test cell will be introduced shortly to enable endurance running to start and a TBO to be established. An initial TBO of 1000 hours for the first engines is expected, but it is considered that this will easily extend to 2000 hours, and more should be available in the future, based on the design technology.

Delivery of the first production engines will commence with the first few at the end of 2001, building up to a full production rate in 2002. Most of the first year s production will go into Europas, other installation planned are Jodel DR1050, Vans RV-9, Thorpe T.211, Longeze and Pelican PL and Murphy Rebel. The inline engine will allow optimised cowlings to produce a lot less drag than with traditional flat four engines, the narrow cowlings will also generally give a better view over the nose for taildraggers, together with more prop clearance due to the higher thrust line.

Once the 3 cylinder engine is into production, the next task will be to continue development into the 4 cylinder WAM 160 version, which should be a great replacement for the popular Lycoming O-320/O-360 range used in many aircraft

Currently all engines are for homebuilt aircraft and development is continuing using the PFA Permit to Fly system, however, once the engine becomes mature, certification will be pursued.

The test aircraft is a Europa, kindly loaned by Bill Williams-Wynne (he now has a Vans RV-6 to fly) and modified to accept the WAM-120 and tis cooling systems by the Wilksch team. As Mark Wilksch said, this sort of co-operation makes great things possible in the PFA arena! Thanks also must go to RAF Bicester for allowing their airfield to be used for the test flying.

Setting off

I sat in the aircraft with Mark while he went through the pre-flight checks and start-up routine. Turning on and setting up the data loggers takes a couple of minutes, but starting the engine is simplicity in itself. Power lever at idle (no it s not a throttle!), turn the key to the first detent to warm the igniters for a couple of seconds, then to START and it fires straight away just like my diesel car! Initially there is the familiar diesel rattle, quickly giving way to a smooth quiet idle at 1000 rpm. The lack of gear drive whine was noticeable (the WAM being a direct drive engine). We then handed over to John Brownlow for the photo mission.

Taxiing away the aircraft was very quiet and on takeoff considerably quieter than the Camera ship 172, or the resident glider tugging Piper Pawnee, with a Hoffman 4 bladed prop and hush kit. In fact as the Europa flew over it seemed most of the noise was from the propeller, rather than the engine and it seemed quieter even than a conventional Rotax powered Europa, although we didn t actually have one there to compare. The photo flight lasted almost one hour and when John came back, there was just a quick check of oil and coolent quantities, plus refuelling with more diesel before he was off again to do some take-off and landings for Ed s camera.

The tanks were dipped and the

consumption for the flight had been 12 litres of diesel that s less than £5. The Europa is signed off for two place operation and I had hoped to act as flight test observer with the aim of taking some in-cockpit noise measurements. However, John chose not to do any two up flights as the ground at Bicester was unusually boggy and John was concerned with the ground handling with the extra weight.

The next step is to finalise the Europa installation; the oil cooler hanging below the cowling will not be required with the new production engine. In parallel with this the first production engines are being assembled first for testing on the test rig, then one will be flown in the Europa and a second in a Thorp T211 being loaned to WAM by A D Aerospace (yet more co-operation between PFA members). Work is now well advanced on the Thorp T211 installation, which should be flying early next year from Hinton-in-the-Hedges with diesel power. The new engine will (initially at least) be approved to fly only on Avtur fuel. The oil company that WAM have used to date have been happy to deliver with a minimum buy of three or four 200litre barrels. With no underground storage required for Avtur, fuel availability, even at smaller PFA airfields appears to be a non-issue.

The Wilksch Team

Mark Wilksch

Mark worked at Cosworth in the early 90s on a project developing a Diesel aero engine together with Teledyne Continental which evolved into a 3 cylinder petrol O-200 replacement, but did not progress. Mark left Cosworth in 1993 and formed Wilksch Airmotive, obtaining DTI development funding which led to the first engine runs of a two cylinder design in January 96. The first flight, in a Piper Cub, occurred in November 97. Further development into the current three cylinder engine continued, together with another DTI award and first flight of this engine in the Europa took place in December 99. Mark flies both light aircraft and motorgliders.

Martin Long

Martin spent seven years at Cosworth, working on Formula One engines and then a project developing a single cylinder 2 stroke petrol/diesel engine. Martin, WAM s Chief Engineer, joined the company almost at the very beginning in January 95 and has been involved in all of the design and development. He also introduced the CAD/CAM system.

Martin s flying experience includes light aircraft, gliders and helicopters.

Steve Dennison

Steve also worked at Cosworth, responsible for engine build and quality control of many customer engines, plus control of all subcontractor produced items. Steve also has a long involvement in restoring and race prepping historic cars and he has recently taken the first steps to gaining a PPL.

Steve s main tasks at WAM are receiving and inspecting the engine components from the suppliers, engine assembly and testing in the on site test cell, and developing and maintaining company QA and computer systems.

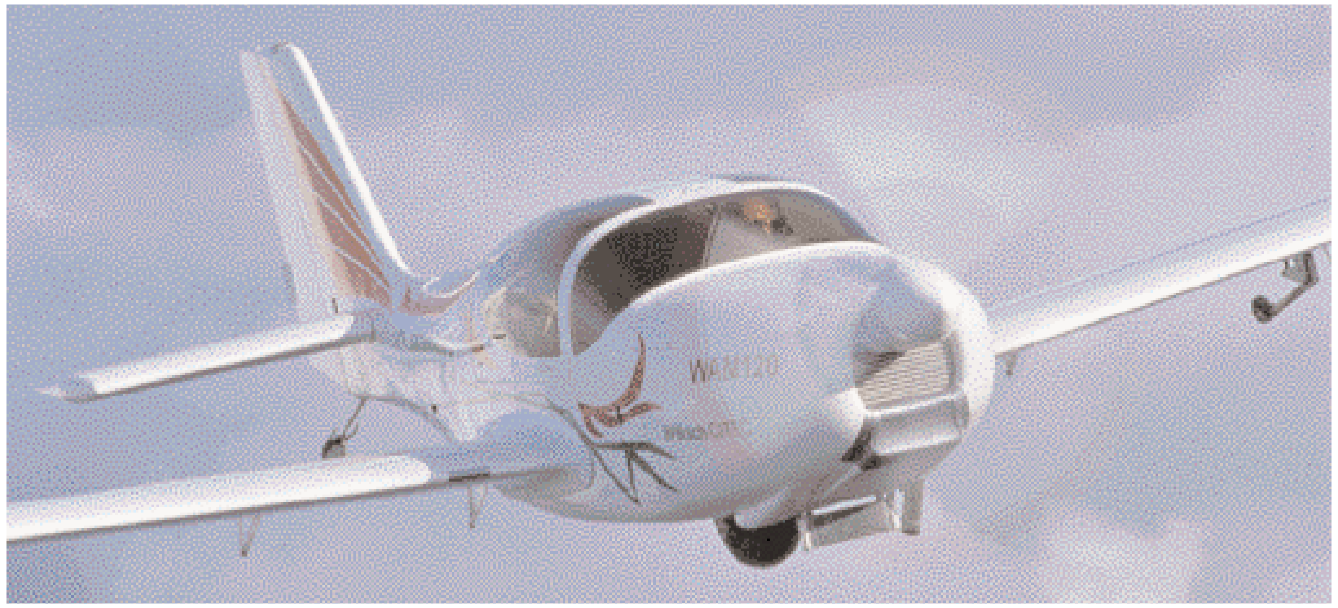
Phil Franklin

Phil is the diesel expert, having worked at the leading edge of diesel technology for a number of years with companies such as Ruston, Holset and AE Goetze. He first worked on large engines for trains and ships that were leaders in technology at the time, then with turbo machinery, which is the real key to power output and efficiency on diesels. He led a team at Holset that developed variable inlet turbochargers, greatly improving their efficiency, for installation on Iveco trucks.

At the other end of the scale he also became involved with Listers, producing their small, run forever diesels for generators, dump trucks and the like. At WAM Phil is the Chief Development Engineer, putting his experience to work to get the best out of the Wilksch engine.

Amanda Wilksch

Actually qualified as an architect, Amanda is WAM s company secretary and runs the company s finances and customer liaison.



Test Flying update with John Brownlow

Over the 5th and 9th October six test flights were made with the aim of assessing cooling efficiency with the new engine, now equipped with a MTV-6D 157 106 propeller, and at higher power settings than were available with the earlier prototype engines and different propellers. Sixteen test flights have now been completed since 2nd January 2001. The new hydraulic MT propeller was fitted in anticipation of the production WAM-120 and its integral oil feed to the propeller and governor mount pad. Until the new engine is available the MT is being used as a ground adjustable.

The punch of the new engine was immediately apparent on opening the throttle for take off on the damp and rather soft grass at Bicester. Timed climbs were made averaging 800 ft/min respectable for a Europa with a fixed pitch propeller, and at an all up weight of around 1250 lbs. A timed climb was also made from brakes off to 3000ft in 5 min 10 sec. The propeller pitch had been ground adjusted to give 2500 rpm in the climb at 80 KIAS.

With the Europa established in level flight at 2000ft and 2650 rpm, 120 KIAS was maintained comfortably, and the oil and coolant temperatures were both well within normal operational limits. This setting equates to around 70 per cent power with the present 100HP rating. As has been the case during the whole test programme, the engine ran very smoothly with a low level of cockpit noise.

In summary, this latest batch of test flights clearly demonstrated the excellent progress being made with the WAM120. Future power increases and a return to a VP propeller promises exciting performance in up-coming test flights

Photo flight

The morning of Tuesday 23 October turned out to be ideal for the Europa Diesel to make her debut before Ed Hicks camera operated from a Cessna Skyhawk flown by Neil Plumb, and as we had all waited for some time for good air-to-air photographic weather the pressure was on! With the briefing completed, and good radio communication established, we took off at midday and I joined the Skyhawk in the number three position. Together we climbed through a convenient gap in the main cloud layer to 4000ft. where there was a wonderful cloudscape surely Ed would be pleased with this and had brought plenty of film?

Flying formation using a diesel engine was a first for me, and there were a number of questions in my mind. Would the response to throttle be comfortable? Would the engine handle like a piston or a jet or something in between? How would the diesel engine itself stand up to almost continuous small throttle movements for an hour or so? After all it was a prototype. How would the engine temperatures, and oil and fuel pressures respond? So far during the test programme I d been able to keep a beady eye on them continually, but on this trip only the occasional glance would be possible. Would there be any unusual torque reaction with power changes that might upset position keeping?

I need not have been concerned. The engine performed perfectly, on this, the longest flight yet, of just under one hour. Response to throttle was good rather more like a jet than a piston. The slip ball stayed in the centre as if locked, as power was changed proving there were no unpleasant torque effects, and all the Ts and Ps settled comfortably in the middle of the operating range for the entire sortie. The Europa is, of course, an easy aeroplane to fly in formation. Trim changes with speed alterations are minimal, the ailerons are crisp and only need finger and thumb treatment to make small lateral alterations of position.

Similarly, nearly instant pitch response generated by the all-flying tail plane makes precise vertical positioning a doddle, and fore and aft positioning was absolutely no problem with the WAM-CITEC diesel providing precise power changes with tiny movements of the throttle. So really the only problem was the soft ground on return to Bicester.

In short, I m confident that the Wilksch diesel will give pilots no problems when flying in formation. Hopefully, Ed s pictures will support this conclusion!

How Diesels Work – Your Questions Answered

There has been a lot of press about aircraft diesel engines, but many articles have assumed a level of knowledge concerning their operation and important features/ requirements that many of us may not possess.

Phil Franklin, WAM s Chief Development Engineer, has therefore kindly provided the following kit-builders guide to aircraft diesels.

Q. What is a diesel engine?

A. An internal combustion engine that uses compression ignition i.e. heat generated by compressing the charge actually ignites the fuel. The tricky bit is getting the fuel to the air at the right time.

Q. What about carburetted and spark ignited 'diesel' engines?

A. These are not strictly diesel engines, and need all the usual SI features and controls. They must be low compression to avoid pre-ignition and hence have limited power output and high fuel consumption. Although they can successfully run on low-cost fuels like Avtur, starting usually requires a more volatile fuel, like gasoline.

Q. Can diesel engines burn Avtur/Jet-A1?

A. They can be designed and built to burn just about any fuel; the most important consideration is ignition quality (at what temperature the fuel ignites). Liquid fuels like Avtur/Jet A are so similar to DERV (Diesel Engines Road Vehicles) that an engine can be designed to use all three. There will be a slight power loss when burning the lower calorific value fuels (Avtur and Jet A), and engines may not start as well at low temperatures due to the greater variability of ignition quality of these fuels. The lower lubricity of these fuels also requires greater robustness from the fuel injection system.

Q. What is the difference between DI & IDI – what do they mean?

A. DI stands for direct injection the fuel is squirted at very high pressure into the air in the combustion chamber (a bowl in the piston) at just the right time. The energy given to the fuel during injection results in minute fuel droplets, hence thorough mixing.

The IDI (Indirect Injection) engine has a small chamber connected to the top of the cylinder which the compressed charge is forced into. The air flowing through the narrow connecting passage breaks up the fuel spray, which is injected at lower pressure than for DI, but again at just the right time. This gives smoother combustion with lower noise but wastes some energy squeezing the air through narrow passages.

Q. Are diesel engines heavier than gasoline engines?

A. Other things being equal yes. Because diesels use higher compression to ignite their fuel they must be stronger, and because the limiting speed of diesel combustion is slower than gasoline combustion, the peak rpm of the diesel is lower. Both factors make the diesel heavier for the same power. However no detonation limit makes the diesel ideally suited to turbo-charging and by using a 2-stroke cycle the gap can be further closed. For direct drive engines (like the traditional Lycontinental) where the rpm is dictated by the prop, a diesel can readily match or beat a gasoline engine.

The 4-stroke diesel is likely to suffer a weight disadvantage but can trade some of this off with lower fuel consumption. By gearing a high speed gasoline engine, a power:weight can be achieved that the diesel cannot match; however unless the requirement is racing, record breaking or perhaps aerobatics, power:weight is not the whole story. Operating cost and durability are important considerations for typical recreational and commercial GA aircraft. Provided that the benchmark power:weight set by the established Lycontinental range can be met, it would seem that diesel aircraft engines have a bright future.

Q. Why are most companies not modifying standard automotive engines?

A. Modern automotive diesels are very efficient, have a wide speed range (for a diesel), a high top speed (to get high specific power) and good low-speed torque. These improvements have largely come from electronic control of injection, so these engines totally rely on electronics, a high power electrical supply and a lubricious fuel, but their weight remains high since power:weight is not their most important consideration, and there is the weight of the gearbox too. Several of these features are not really what the aircraft market wants: it wants simplicity, high power to weight, and reasonable efficiency with wide fuel capability to be able to burn the gas turbine fuels.

Q. What is the truth on fuel consumption?

A. Again not a clear cut issue. Fundamentals of compression ratio and lean operation mean that the diesel is inherently more efficient. A modern gasoline car engine running lean is efficient (about 270g/kWhr) but only at one condition. Believe it or not, a Lycoming designed 40 or more years ago can match this figure while leaned to perfection in the cruise. During a high power climb however the figure jumps to over 350gm/kWhr. A DI car diesel engine can achieve 210g/kWhr and an IDI about 250g/kwhr; 4 strokes are a little more efficient than 2-strokes.

Where diesels really score is because their efficiency is flat over most of their operating envelope and they never need fuel cooling . The latest electronic wizardry does a lot for a gasoline engine but it will never beat a good diesel.

Q. Talking of cooling, what is the story here?

A. Diesels, like petrol engines, need to get rid of their waste heat. Because they are in general more efficient they do not have quite so much heat to loose, particularly in the case of DI, although a slightly higher proportion ends up in the coolant. For aeroplanes the important factors are mass and bulk of cooling pack and drag.

Highly rated diesels use intercoolers to reduce the temperature of the supercharged air and hence increase its density. This means that cooling pack design is an interesting challenge that will no doubt result in some interesting solutions! The requirement for high ratings and long life (without cracks!) gives air cooling a low chance of success.

Q. What about longevity? Won't highly rated diesels be fragile?

A. Properly designed and developed liquid cooled diesels will enjoy long lives like their automotive cousins. Low piston speeds mean low wear rates; lack of wall-wetting by fuel means low ring, piston and bore wear; low speeds mean low valve gear accelerations and wear; substantial cranks and bearings will cope with high cylinder pressures. With water cooling, thermal cracking should be a thing of the past, and of course those with direct drive will have no gearbox problems. X

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