the everest parajet engine

Q. How do you make an engine light enough to carry on a pilot's back - yet twice the power of an average paramotor, and it's got to do all this while flying at 30,000ft?

A: My partner in the Parajet rotary engine project (it will be the world's first Wankel rotary-engined paramotor) Paul Woelfle from Aixro in Germany had already designed a larger rotary engine for kart racing and this seemed like the perfect choice. It weighed 17kg and produced 48 horsepower. By the time I had finished taking every extra component off it such as the clutch, carburetor, fuel pump, engine mounts, gear drive, and machined the weight out from every conceivable other component, including the main drive rotor, balancing shaft, side plates, exhaust and manifolds, I had a 254cc engine that weighed only 11kg, produced 48 hp at 9000rpm and was only 130mm wide, front to back.

Now it was time to make it produce almost double the power. This was achieved by fitting the Rotrex supercharger. By forcing air into the combustion chamber under high pressure, this engine could actually produce more than double the power and because it already had a low compression ratio of 11:1 it wasn't necessary to alter the engines mechanical components, ratios etc.

The Supercharger

There many problems with the supercharger installation.

Firstly, creating a reliable drive system from a single rotor engine to a supercharger is extremely demanding on the mechanical components. The power pulses are so intense as the engine fires that the drive belts shatter and break up. Belts that were designed to take up 50 horsepower were disintegrating in minutes and the belt tension, which was critical to the longevity of the belt was outside the experience of belt specialists. And the speed 200,000rpm at which the supercharger needed to be spun didn't help. It took four months of relentless redesigning and rebuilding to come up with a system that truly worked.

Secondly, Heat removal was a major problem. I ended up making a small 2500cc intercooler fitted directly into the airflow yet positioned as to close the engine as possible. This reduced the inlet temperature from 100°C to 40°C.

The next problem was to set the correct supercharger pressure

ratio against engine rpm. If the supercharge output isn't matched to the demand from the engine the impellor blades stall and the whole system ends up worse than if you just left the engine normally aspirated. There was no prior experience in the extreme conditions, so we had to spend hundreds of hours testing in a hyperbaric chamber. Eventually I settled for a ratio that provided the engine with just enough air pressure, though not as much as I would have liked.

Then the supercharger had to be driven 20% harder than it was designed to, creating extra heat. This caused the impeller blades to expand slightly and contact the housing which destroyed the supercharger more than once. The housing had to be re-machined, but only by trial and error as the rate of expansion was impossible to calculate since finding out the actual temperatures of the vanes was just too complex.

The Engine Computer control system:

The Everest engine parameters were controlled entirely by computer; the ignition timing, fuel injection timing, manifold pressure, liquid cooling and of course the automatic altitude compensating system.

I used an MBE chip as this was easily programmable and had a facility to incorporate manifold pressure-based fuel delivery. This was a simple way to make the engine understand what to do as the altitude increased. Once the system was working it was necessary to work out how much fuel needed to be injected. This process took 2 months of flight trials and ground testing the engine on a thrust rig both in and out of the hyperbaric chamber.

Powering the engine electronics:

The engine consumed a lot of electrical power. The liquid cooling system, ignition system, injector, fuel pump and ECU together drew 15 amps. I had to develop a tiny 3 phase generator as any conventional alternator that was readily available was far to heavy and meant more drive systems.

The tiny system was driven attached directly to the rear drive-shaft after the supercharger transmission system. It consisted of 12 Neodymium magnets mounted around a small magnetic stainless rotor. This spun on the shaft inside a specially wound stator, coil and regulator. The result was a reliable 14.volt charge to the tiny 3 amp 12volt lead acid gel cell that I used to keep things as light as possible.

The engine cooling system:

The rotary engine is liquid-cooled, which makes it more efficient and lighter than an equivalent air cooled rotary engine. It did however make things more complicated since at high altitude the air density is so low that cooling radiators need to be made larger than at sea level. Although the air temperature is lower this does make up for the cooling inefficiencies of low pressure air and the radiator had to be made 50% larger and mounted directly in the most exposed position in front of the propeller.

The Starter:

The first engine was designed and built with the start motor and electronics incorporated into the design. After all the design issues were discovered with the supercharger and the weight penalty of a basically redundant starter motor was established, the starter motor was removed and the supercharger moved into it's position as close to the engine as possible. I used an external hand held starter motor instead which was more reliable and powerful and fitted onto the rear of the engine during the start up procedure.

The teamed arrived in Kathmandu on 8 May. We were soon on board a MI-17 Russian cargo helicopter and heading up into the Mountains with all our equipment. We had on board two Everest paramotors, 100 litres of special oxygenated fuel, a complete portable engineering workshop including spare engines and every other conceivable Parajet component, five sets of spare propellers, our special 36sq metre Everest paragliders designed and made by Mike Campbell Jones, a complete weather balloon satellite tracking system and enough tents for all of us, the film crew of seven and another 30 porters. We also had three generators and a further 150 litres of diesel - in all nearly 2500kg of equipment.

To me it seemed so ridiculous that we needed such a huge amount of equipment just to fly two of the smallest types of aircraft in the world over Everest, but somehow every box that I'd packed was filled with bits that were necessary to make the expedition possible…it's amazing how much equipment one needs for these projects.

Monday 14th May

Terry woke us all up at about 4.00am on Monday morning as the weather was perfect. We rushed around and got all our kit on, everything was moved into place on the airstrip and once everything was in place we fired off a weather balloon. It rose to 28,000ft and registered no more than 4mph all the way up. This was our lucky day; there was not a cloud in the sky, and the conditions could not have been anymore perfect.

We were ready in good time, sitting with our machines and wings on the airstrip with umbrellas to shade us from the hot morning sun, waiting for the catabatic winds to switch. At around 8.20am the wind switched to anabatic and within minutes Bear was in the air and circling above us. Moments later I had my helmet on and the machine roaring away in my back; I took off first time, the wing launching perfectly and with three steps I was in the sky and climbing at 600-700ft/min. I checked all my lines, speed bar, and oxygen system and reserve parachute. Everything was perfect and I settled down and started really enjoying the flight. I backed off the throttle a little and was climbing steadily at 400-500ft/min.

The air was glassy smooth as I circled up and up above our base camp. I could see Everest clearly now behind the 25,000ft Nuptse Wall. It had been hidden from us all week and now there it was still towering above me only a few miles away.

Soon I was above the summit of Amadablam at 23,000ft, my QuestVario working well, still showing a climb of 500ft per minute. I was just below Bear at this stage, and still catching up. I could see a huge area of the Everest's south face now where it had been hidden behind the Nuptse wall.

Our flight plan was to stay south of the Nuptse wall, the highest vertical wall on the planet. Originally we had planned to fly directly over the summit of Everest but for three reasons had made a difficult decision to change our flight plan.

1) We were not granted a permit by the Nepalese to fly over the Nuptse Wall

2) We risked being blown over Everest and into Tibet where we had been denied permits to fly

3) If we had an engine failure beyond the Nuptse Wall it meant serious trouble, between here and Everest there is nowhere to land below 20,000ft and we didn't want to take such a risk.

Before long I was looking down on the Nuptse wall at 25,000ft by which time I had my variometer and GPS freeze up. I flew right up to the Nuptse wall trying to get as close to Everest as possible. The air was so still up there I was so tempted to blow our flight plan and just fly right up to the summit and skim over it… this was the ultimate dream!

As I kept on climbing I looked across at the peak and it seemed almost level with me now. I checked my oxygen saturation on the wrist monitor and realized the connector had come un-clipped; the screen was blank and there was no way with my massive gloves on that I could re-connect it. Instead I looked at my reservoir oxygen bottle to check the bag was still inflating inside. It was perfect and while my hands were getting very cold, I felt great, both physically and mentally.

I'd not had time to test the engine in the hyperbaric chamber and the performance at altitude was just not up to scratch; I could feel it begin to struggle on my back. Bear was still going higher and higher above me, becoming a speck after another 10 minutes or so and as I was clearly not climbing any higher now I made the difficult decision to switch off my engine. Once switched off there was no way to re-start so that was Mission over for me.

I looked up again at Bear and then heard him on the radio saying he had done it, he was looking down on the Summit from a few miles away to the south. The video microwave link came through clearly to our base station screens and I heard a crowd of people cheering as they saw what Bear was seeing. With no mountains left above him he decided to fly one lap 15,000ft above our base camp and fly down to safety.

Judging from my position in the mountains, I was looking down on the 25,000ft Nuptse Wall, and yet up at Bear flying above me, the maximum altitude I reached must have been between 27,000ft and 28,000ft. Looking up at Bear it just felt like a massive success. The fact that I'd already had suspicions about the second engine, it had never even been flown before…frankly I think I was lucky to have got as high as I did.

It took about 30 mins to get down. I was warm but my hands were still freezing. When I landed on the helipad in Pheriche, a man was walking across just stopped and stood there looking at me, exactly where I where I had planned to land. In the end I had to change my approach to avoid him and landed five metres or so away. My wing fell to one side on the man who refused to move! He then took a photo of me from under my canopy and later claimed that it was Bear who had landed on top of him!

Bear was still 5000ft or so above me and the wind was picking up in the valley, his engine having switched itself off on his final lap. He landed just near me 15 minutes or so later and the whole GKN team, all 100 porters and trekkers came down the hill to celebrate.

Soon after we landed the wind picked up to 20 mph or more, clouds came rolling up the valley and we realized quite how lucky we were - we'd taken our two hour window and that was all we were going to get.

It was a massive amount of work to pack into seven months, and the project had so many risks, if our oxygen systems failed we were likely to die, we had no room for reserve anything so we just had to hope for the best. All in all, I feel we were just enormously lucky out there.

Someone was looking after us…that was for sure!