Hyper engine

The **hyper engine** was a hypothetical aircraft engine design, an engine that would be able to deliver 1 horsepower per cubic inch (46 kW/L) of engine displacement. The term was used only in the United States, where the Army Air Corps funded development of a hyper engine of about 1200 cubic inches (20 L) in the 1930s, hoping the engine's small size would lead to better streamlining and improved range. None of these designs entered production, by the time they were ready new aircraft designs were demanding much larger engines.

Background

During the 1930s designers were looking to the future of engine development, and the need for engines of about 1 hp/in³ became an obvious target. It was clear that this sort of performance would not be easy to achieve. A typical large engine of the era, the Pratt & Whitney Twin Wasp, developed about 1,200 hp (895 kW) from 1,820 in³ (30 L), so an advance of some 50% would be needed. As the ultimate design goal was a favourable power-to-weight ratio for long-range airliners and bombers, which needed to be able to lift huge fuel loads and still have extra capability left over for cargo and passengers, simply scaling up an existing design was no solution. While it would have increased the total available power, it would not have any dramatic effect on the power-to-weight; for that more radical changes were needed.

Improvements in construction and lighter materials had already delivered some benefits. Aluminum cast-block engines were rapidly improving in quality in the early 1930s and had lowered engine weight noticeably. However, another 50% savings simply wasn't there. To reach that goal engines would either have to extract more power from the fuel, or alternately run at a higher speed (more "bangs" deliver more power).

Engines were already fairly efficient, so in order to extract more power they would have to increase the amount of fuel/air mixture, the *charge*, either by growing larger or using a supercharger to force more charge into the engine. The whole idea of the hyper concept was to remain small, so only the second solution would help in this case. However, at the time the entire industry used 87 octane fuels and were already running near the compression ratio limit for that fuel (about 6.5 to 1). Increasing compression, although mechanically possible, would lead to ping and potentially damage the engine.

Increasing RPM looked considerably more attractive. At the time a number of problems hampered this way forward, notably problems with the poppet valves used in most engines. At higher operating speeds they simply could not open and close fast enough to keep up with the engine. Additionally the exhaust valves tended to heat up so much they created hot-spots inside the cylinder that could also lead to ping. Several solutions to the valve problem were known in the 1930s. In England, Harry Ricardo had become a proponent of the sleeve valve system for exactly these reasons, and had some success convincing British engine companies to invest in the idea, notably Bristol Engines, where Roy Fedden became "a believer". Ricardo's flatmate and friendly competitor, Frank Halford, designed his own sleeve valve engine, which was picked up by Napier & Son.

The first Hypers

Ironically it was one of Ricardo's papers on the sleeve valve design that led to the US's hyper engine efforts. In one late 1920s paper he claimed that the 1 hp/in³ goal would be impossible to achieve with poppet valve engines, and US Army Air Corps engineers at Wright Field decided to test this claim by breaking it.

Starting with the 4 3/8th inch bore cylinder from the famous Liberty L-12, they shortened the stroke from 7 to 5 inches in order to allow higher RPM, creating an 84 in³ cylinder they intended to be built into a V-12 engine of 1008 in³. Another change was to use overhead cams pushing multiple smaller valves per cylinder to improve airflow, and to cool the valves with liquid sodium to prevent hot spots. They also used glycol for engine cooling, allowing the cooling fluid to be run at 300° F and thus removed more heat for any given volume of fluid. Although this did not affect performance directly, it would allow for a smaller volume of fluid to be used, reducing the size of both the engine and radiator and allowing for better streamlining.

The Army signed a development contract with Continental Motors in 1932 to develop the design, although Continental's role was generally limited to construction and testing, the actual engineering development being carried out by the Army. The first test engine, the single-cylinder **Hyper No.1**, first ran in 1933. However the Army apparently became concerned about the development of a suitable supercharger for high-altitude use, and for further development in 1934 they asked for a newer cylinder with slightly less performance with a volume of 118.8 in³. This would be used in a similar 12-cylinder engine with a total displacement of 1425 in³ delivering the same 1000 hp, with a performance of 0.7 hp/in³. This placed its performance on a par with newer experimental engines from Europe like the Rolls-Royce Merlin, at least when run on the higher octane fuels the Army planned to use.

Another change was to the layout; the Army became convinced that future designs would use engines buried in the wings for additional streamlining, and asked Continental to design a full-sized engine with a flat-opposed layout suitable for installation inside a wing. This led to the Continental O-1430, which would require an extensive ten year development period before becoming reliable enough to consider for full production in 1943 (now known as the IV-1430). By this point other engines had passed its 1,600 hp (1,200 kW) ratings, and while the IV-1430 had a better power-to-weight ratio, there was little else to suggest it was worthwhile setting up production in the middle of the war.

Other examples

Continental's engine was not the only one to be developed using the Hyper cylinder principles. Lycoming spent almost as much time on their 1,275 hp (951 kW) O-1230, and found much the same reception when it was ready for production in 1939. They tried again by bolting two O-1230's together into the H-2470 H engine, and while this engine was planned for use in the P-53, this plane did not go into production, and neither did the engine. Ford also worked on their V-1650 based on the hyper principles, but this saw almost no interest.

Generally the problems with the designs were not so much technical as that they were simply providing too little total power. By the time they were ready for production the aircraft industry was demanding much more power from any new design than they could yield. Re-engining existing airframes designed for 1,200 hp (890 kW) class engines may have resulted in a performance increase, but even for that a major airframe re-design would have been required to take the full advantage of a buried engine. Such a redesign was not considered worthwhile, mostly because much larger aircraft with considerably more performance would be available at about the same time.

Ironically, by the end of the war most engines were technically hypers due to improved charge - the very solution considered not viable in the 1930s. This was due to ever increasing octane ratings of the available fuels. Pre-war engines generally ran on 87 octane fuel, but just prior to the opening of the war the British arranged for a supply of 100 octane fuel from the US and others. This led to an immediate boost in power for all supercharged engines then in service. By the end of the war the Rolls-Royce Merlin could deliver bursts of up to 2,000 hp (1.5 MW) from 1650 in³ (27 L), running on 150 octane fuel and dramatically increasing supercharger boost levels. Of course the same was also true of the Napier Sabre, whose late-war prototypes delivered a whopping 3,500 hp (2.6 MW). The earlier Sabre V delivered 1.36 hp/cubic inch.

See Also

- Chrysler IV-2220 16 cylinder inverted V
- Pratt & Whitney H-2600 'X-1800' 24 cylinder sleeve valve H-type [[1]]
- Pratt & Whitney H-3730 'H-3130' 24 cylinder sleeve valve H-type