Tractor configuration

Aerotechnik EV97A Eurostar, a tractor configuration aircraft, being pulled into position by its pilot for refuelling.

An aircraft constructed with a **tractor configuration** has the engine mounted with the propeller facing forwards such that the aircraft is "pulled" through the air, as opposed to the pusher configuration in which the propeller faces backwards and the aircraft is "pushed" through the air.

In the early years of powered aviation both tractor and pusher designs were common. However, by the mid-point of the First World War, interests in pushers declined and the tractor configuration dominated such that today all propeller-driven aircraft are assumed to be tractors unless stated otherwise.

From a military perspective, the problem with single-engine tractor aircraft was that it was not originally possible to fire a gun through the propeller arc without striking the propeller blades with bullets. Early solutions included mounting guns (rifles or machine guns) to fire around the propeller arc, either at an angle to the side — which made aiming difficult — or on the top wing of a biplane so that the bullets passed over the top of the propeller.

The first system to fire through the propeller was developed by French engineer Eugene Gilbert for Morane-Saulnier and involved fitting metal "deflector wedges" to the propeller blades of a Morane-Saulnier L monoplane. It was employed with immediate success by French aviator Roland Garros and was also used on at least one Sopwith Tabloid of the Royal Naval Air Service.

The final solution was the interrupter gear, also known as "synchronization gear", developed by Fokker and fitted to the Fokker E.I monoplane in 1915. The first British "tractor" to be fitted with synchronization gear was the Sopwith 1½ Strutter which did not enter service until early 1916.

Other solutions to avoiding the propeller arc include passing the gun's barrel through the propeller's spinner (the nose of the aircraft) or mounting guns in the wings. The latter solution was generally used from the early 1930s until the beginning of the jet age.

Pusher configuration

A British WWI-era F.E.2b pusher. The propeller is just behind the wing.

An aircraft constructed with a **pusher configuration** has the engine mounted with the propeller facing backwards such that the aircraft is "pushed" through the air, as opposed to the tractor configuration in which the aircraft is "pulled" through the air.

Many early aircraft were **pushers**, including the Wright Flyer and the Curtiss plane used by Eugene Ely for the first ship take-off. In the early years of the First World War pushers were favoured by the British because they enabled a forward-firing gun to be used without being obstructed by the arc of the propeller. Such aircraft included the Vickers F.B.5 Gunbus, the Royal Aircraft Factory F.E.2 and the Airco DH.2. (Germany did not have the same requirement due to the early development of Fokker's interrupter gear.)

The pusher configuration on a Rutan Long-EZ home-built aircraft.

Single-engine pushers usually had the engine mounted on the centreline at the rear of the aircraft's nacelle. Such aircraft had no fuselage, the tail section being mounted on a framework that cleared the propeller.

With the widespread adoption of interrupter gear, most benefits of the pusher configuration were lost and the tractor configuration was favoured. Pushers did not become extinct after the war but were a minority of new aircraft designs. The 1930s Supermarine Walrus was a seaplane with a single pusher engine. Large multi-engine aircraft, such as the Short Singapore, continued to be built with a push-pull configuration, combining the tractor and pusher configuration. Possibly the most extreme example of the type is the Convair B-36, the largest bomber ever operated by the United States, which wing-mounted six 3,800 hp Pratt & Whitney Wasp Major radial engines in a pusher configuration, augmented in the B-36D by four General Electric J47 turbojets. The Saab 21 was also initially built as a pusher since jet engines were not be available. Arguably the most common ultralight, the Quad City Challenger, also has a pusher configuration.

Advantages

Efficiency can be gained by mounting a propeller behind the fuselage, because it re-energizes the boundary layer developed on the body, and reduces the form drag by keeping the flow attached. However, this effect is not nearly as pronounced on a small airplane as it is on a submarine or ship, where it is quite important due to the much higher Reynolds number at which they operate.

Wing efficiency increases due to the absence of prop-wash over any section of the wing.

Rear thrust is somewhat less stable in flight than with a tractor configuration. This has the potential to make an aircraft more maneuverable.

Visibility of a single-engined airplane is improved because the engine does not block forward vision. Consequently, this configuration was widely used for early combat reconnaissance aircraft, and remains popular today among ultralight aircraft.

The propeller of a single-engined airplane can be placed closer to the elevators and rudder as illustrated in the picture of the Royal Aircraft Factory F.E.2 above. This increases the speed of the air flowing over the control surfaces, improving pitch and yaw control at low speed, particularly during takeoff when the engine is at full power. This can be beneficial while bush flying, especially when taking off and landing on airstrips bounded by obstacles that must be avoided while the airplane is moving slowly.

Disadvantages

The pusher configuration can endanger the aircraft's occupants in a crash or crash-landing. If the engine is placed behind the cabin, it may drive forward under its own momentum during a crash, entering the cabin and injuring the occupants. Conversely, if the engine is placed in front of the cabin, it can act as a battering ram and plow through obstacles in the airplane's path, providing an additional measure of safety.

Crew members may strike the propeller while attempting to bail out of a single-engined airplane with a pusher prop. This potentially gruesome scenario helps to explain why pusher props have rarely been used on post-WWI fighters despite the theoretical increase in maneuverability.

A less dire but more practical concern is foreign object damage. The pusher configuration generally places the propeller(s) aft of the main landing gear. Rocks, dirt or other objects on the ground kicked up by the wheels can find their way into the prop, causing damage or accelerated wear to the blades. Also, some centerline pusher designs (such as the Rutan Long-EZ pictured above) place the propeller arc very close to the ground while flying nose-high during takeoff or landing, making the prop more likely to strike vegetation when the airplane operates from a turf airstrip.

When an airplane flies in icing conditions, a layer of ice can accumulate on the wings. If an airplane with wing-mounted pusher engines experiences wing icing and subsequently flies into warmer air, the pusher props may ingest pieces of ice as they shed, posing a hazard to the propeller blades and other parts of the airframe that can be struck by chunks of ice flung by the props.

The propeller increases airflow around an air-cooled engine in the tractor configuration, but does not provide this same benefit to an engine mounted in the pusher configuration. Some aviation engines experience cooling problems when used as pushers. Likewise, the pusher configuration can exacerbate carburetor icing. Some air-cooled aviation engines depend on air heated by the cylinders to warm the carburetor(s) and discourage icing; the pusher configuration can reduce the flow of warm air, facilitating the formation of ice.

Propeller noise often increases because the engine exhaust flows through the props. This effect is particularly pronounced when using turboprop engines due to the large volume of exhaust they produce. Aviation enthusiasts can often hear a Piaggio P180 Avanti approach due to the loud high-pitched wail produced by the engine exhaust blowing through the props.

Vibration can be induced by the propeller passing through the wing downwash, causing it to move asymmetrically through air of differing energies and directions.

Problems may emerge when using wing flaps on a pusher airplane. First, the absence of prop-wash over the wings can slow the airflow across the flaps, making them less effective. Second, wing-mounted pusher engines block the installation of flaps along portions of the trailing edges of the wings, reducing the total available flap area.

Placement of the propeller in front of the tail (as referenced in Advantages) can have a negative side effect- strong pitch and yaw changes may occur as the engine's power setting changes and the airflow over the tail correspondingly speeds up or slows down. Aggressive pilot corrections may be required to maintain the desired flight path after changing the power setting.