**Fluid coupling**

|  |
| --- |
| A **fluid coupling** is a [hydrodynamic](http://en.wikipedia.org/wiki/Hydrodynamics) device used to transmit rotating mechanical power. It has been used in [automobile](http://en.wikipedia.org/wiki/Automobile) [transmissions](http://en.wikipedia.org/wiki/Transmission_%28mechanics%29) as an alternative to a mechanical [clutch](http://en.wikipedia.org/wiki/Clutch). It also has widespread application in marine and industrial machine drives, where variable speed operation and/or controlled start-up without shock loading of the power transmission system is essential. They are also sometimes called a **fluid flywheel**, a term particularly associated with [Daimler](http://en.wikipedia.org/wiki/Daimler_Motor_Company) cars. |

**Overview**

A fluid coupling consists of a sealed chamber containing two [toroidal](http://en.wikipedia.org/wiki/Toroid)-shaped, vaned components, the [pump](http://en.wikipedia.org/wiki/Impeller) and [turbine](http://en.wikipedia.org/wiki/Turbine), immersed in fluid (usually [oil](http://en.wikipedia.org/wiki/Oil)). The pump or *driving torus* (the latter a [General Motors](http://en.wikipedia.org/wiki/General_Motors_Corporation) [automotive](http://en.wikipedia.org/wiki/Automotive) term) is rotated by the [prime mover](http://en.wiktionary.org/wiki/prime_mover), which is typically an [internal combustion engine](http://en.wikipedia.org/wiki/Internal_combustion_engine) or [electric motor](http://en.wikipedia.org/wiki/Electric_motor). The pump's motion imparts a relatively complex centripetal motion to the fluid. Simplified, this is a centrifugal force that throws the oil outwards against the coupling's housing, whose shape forces the flow in the direction of the *turbine* or *driven torus* (the latter also a General Motors term). Here, [Coriolis force](http://en.wikipedia.org/wiki/Coriolis_force) reaction transfers the angular fluid momentum outward and across, applying [torque](http://en.wikipedia.org/wiki/Torque) to the turbine, thus causing it to rotate in the same direction as the pump. The fluid leaving the center of the turbine returns to the pump, where the cycle endlessly repeats.

**Automotive applications**

In [automotive](http://en.wikipedia.org/wiki/Automotive) applications, the pump typically is connected to the [flywheel](http://en.wikipedia.org/wiki/Flywheel) of the [engine](http://en.wikipedia.org/wiki/Internal_combustion_engine)—in fact, the coupling's enclosure may be part of the [flywheel](http://en.wikipedia.org/wiki/Flywheel) proper, and thus is turned by the engine's [crankshaft](http://en.wikipedia.org/wiki/Crankshaft). The turbine is connected to the input shaft of the [transmission](http://en.wikipedia.org/wiki/Transmission_%28mechanics%29). As engine speed increases while the transmission is in gear, [torque](http://en.wikipedia.org/wiki/Torque) is transferred from the engine to the input shaft by the motion of the fluid, propelling the vehicle. In this regard, the behavior of the fluid coupling strongly resembles that of a mechanical [clutch](http://en.wikipedia.org/wiki/Clutch) driving a [manual transmission](http://en.wikipedia.org/wiki/Manual_transmission).

Fluid flywheels, as distinct from [torque converters](http://en.wikipedia.org/wiki/Torque_converter), are best known for their use in [Daimler](http://en.wikipedia.org/wiki/Daimler_Motor_Company) cars in conjunction with a Wilson [pre-selector gearbox](http://en.wikipedia.org/wiki/Pre-selector_gearbox). Daimler used these throughout their range of luxury cars, until switching to automatic gearboxes with the 1958 [Majestic](http://en.wikipedia.org/wiki/Daimler_Majestic). Daimler and [Alvis](http://en.wikipedia.org/wiki/Alvis_Cars) were both also known for their military vehicles and armoured cars, some of which also used the combination of pre-selector gearbox and fluid flywheel.

**Aviation applications**

The most prominent use of fluid couplings in aero applications was in the [Wright turbo-compound](http://en.wikipedia.org/wiki/Wright_R-3350) reciprocating engine, in which three power recovery turbines extracted approximately 20 percent of the energy (about 500 HP or 375 kW) from the engine's exhaust gases and then, using three fluid couplings and gearing, converted low torque high-speed turbine rotation to low-speed, high-torque output to drive the [propeller](http://en.wikipedia.org/wiki/Propeller).

**Stall speed**

An important characteristic of a fluid coupling is its stall speed. The stall speed is defined as the highest speed at which the pump can turn when the turbine is locked and maximum input power is applied, a condition which could occur in an automobile if the driver were to fully open the throttle while applying the [brakes](http://en.wikipedia.org/wiki/Brake) with a force sufficient to keeping the vehicle from moving. Under stall conditions, all of the engine's power would be dissipated in the fluid coupling as heat, possibly leading to damage.

**Slip**

A fluid coupling cannot achieve 100% efficiency in power transmission, as some of the energy transferred to the fluid by the pump will be lost to [friction](http://en.wikipedia.org/wiki/Friction) (transformed to heat). As a result, the turbine will always spin slower than the pump, this difference increasing with an increase in load on the coupling and/or a decrease in [prime mover](http://en.wiktionary.org/wiki/prime_mover) speed. This speed difference is called *slip* or *slippage*.

**Turbulence**

Also affecting the fluid coupling's [efficiency](http://en.wikipedia.org/wiki/Efficiency) is the fact that the fluid returning from the turbine to the pump when there is a large difference in speed between the pump and turbine is moving counter to the direction of the pump's rotation, resulting in some braking effect and a good deal of [turbulence](http://en.wikipedia.org/wiki/Turbulence). This effect substantially increases as the difference between pump and turbine speed increases, causing [efficiency](http://en.wikipedia.org/wiki/Efficiency) to rapidly deteriorate with increasing load or at reduced rotational speed.

**Calculations**

Generally speaking, the power transmitting capability of a given fluid coupling is exponentially related to pump speed, a characteristic that generally works well with applications where the applied load doesn't fluctuate to a great degree. The torque transmitting capacity of any hydrodynamic coupling can be described by the expression *r*(*N*5)(*D*2), where *r* is the mass density of the fluid, *N* is the impeller speed, and *D* is the impeller diameter. In the case of automotive applications, where loading can vary to considerable extremes, *r*(*N*5)(*D*2) is only an approximation. Stop-and-go driving will tend to operate the coupling in its least efficient range, causing an adverse effect on [fuel economy](http://en.wikipedia.org/wiki/Fuel_economy_in_automobiles).

**Usage**

Fluid couplings were used in a variety of early [semi-automatic transmissions](http://en.wikipedia.org/wiki/Semi-automatic_transmission) and [automatic transmissions](http://en.wikipedia.org/wiki/Automatic_transmission). Since the late 1940s, the more versatile [hydrodynamic torque converter](http://en.wikipedia.org/wiki/Torque_converter) has replaced the fluid coupling in [automotive](http://en.wikipedia.org/wiki/Automotive) applications. Fluid couplings are still widely used in industrial applications, especially in machine drives that involve high inertia starts or constant cyclic loading.