Helicopter Crashes Caused by Freewheel Disengagements

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Helicopters can land safely after the engine loses power because the rotor blades can continue to turn, or autorotate, and provide lift. Autorotation is enabled by inserting a freewheel between the engine and the rotor. The freewheel locks the engine to the rotor when the engine is applying power to the rotor, but disengages the rotor from the engine if the engine stops unexpectedly. In this way a stopped engine does not brake or slow the rotor.

There have been some helicopter crashes where the freewheel suddenly disengaged leading to an engine over-speed and subsequent shutdown. Freewheel damage was moderate so the rotors could still turn freely, but autorotation was unsuccessful because of an operational factor such as low altitude or high rate of ascent. In the Sikorsky accident shown in Figure 1, as well as in other accidents, the freewheel device meant to prevent an accident has instead caused one.

Figure 1. A Sikorsky helicopter engaged in heli-logging crashed after a freewheel disengagement.

The freewheel of this Sikorsky helicopter consists of 12 rollers pinched between a flat cam on the engine side and a gear housing on the rotor side, as shown in Figure 2. When the engine applies torque, each roller is held in place by friction so long as the coefficient of friction (COF) is at least 0.06. If the COF is less than 0.06, the roller will slide off the cam flat. This is called a spit-out. A roller spit-out often leads to a sudden freewheel disengagement at high engine load.

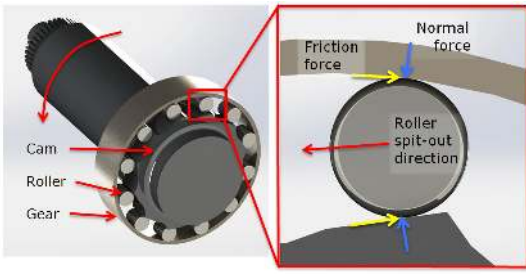

Figure 2. Left: The engine turns the cam causing the cam flats to pinch the rollers against the inside of a gear. That gear drives the main gearbox and ultimately the rotor. Right: If the coefficient of friction is less than 0.06 then the roller will spit out and the freewheel can disengage.

Engineers often assume that the COF between two materials is constant across all loading conditions. This assumption, however, is not always valid. Figure 3 shows data from more than 500 laboratory tests of the friction between the rollers and cams of this freewheel. The data show the COF is not constant and is sometimes less than the minimum value (0.06) needed to prevent a roller spit-out.

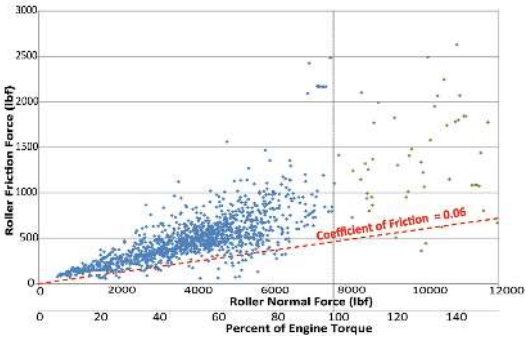

Figure 3. Each data point represents the normal and tangential load on a roller that slid on a cam flat in the laboratory. The line represents the coefficient of friction of 0.06 necessary to prevent roller spit-out. Data points below the line are where the COF is low enough for roller spit-out.

A low COF at high engine torque is believed to have caused freewheel disengagements that led to a number of crashes of this aircraft type engaged in heli-logging. Heli-logging is a repetitive external lift (REL) activity that this aircraft was not originally designed for.

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