Helicopter Crashes Caused by Freewheel Disengagements

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.

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.

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.

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.
PRACTICE GROUPS

Transportation
MEA Forensic's Transportation Group applies engineering and scientific principles to identify the causes and factors contributing to transportation crashes and losses.

Injury
Our Injury Biomechanics Group combines knowledge of injury/impact biomechanics, anatomy, and human performance to determine how injuries are caused and prevented.

Product
Our Product Group blends a thorough knowledge of material behavior, product design, failure analysis, and human factors to determine how and why a loss or injury occurred.

Property
Our Property Group's strong knowledge of mechanical, materials, and civil engineering helps clients uncover the chain of events or conditions leading to a property loss.

Aviation
Our Aviation Group brings together mechanical engineers, material scientists and experienced pilots to investigate the causes of airplane and helicopter accidents and incidents.