Special FAR 73

Overview

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Background:

- Due to its light weight (and therefore low inertia) rotor system, the R22 is not forgiving of pilot error or sluggishness. Why do so many flight schools use the R22 for training? It is cheap to buy and operate. The result has been a relatively large amount of training accidents. The Special Federal Aviation Regulation No. 73 was issued to address the issue and reduce the number of accidents.

Purpose:

- Minimum training and experience for:
  - Students, pilots and instructors in:
    - Robinson R22 and R44

SFAR 73 talks about 2 different types of training:

- Awareness training (Ground training)
- Flight training

Awareness training - § 2 (a)(3):

I. Energy management
II. Mast bumping
III. Low rotor RPM blade (rotor) stall
IV. Low "G" hazards
V. Rotor RPM decay

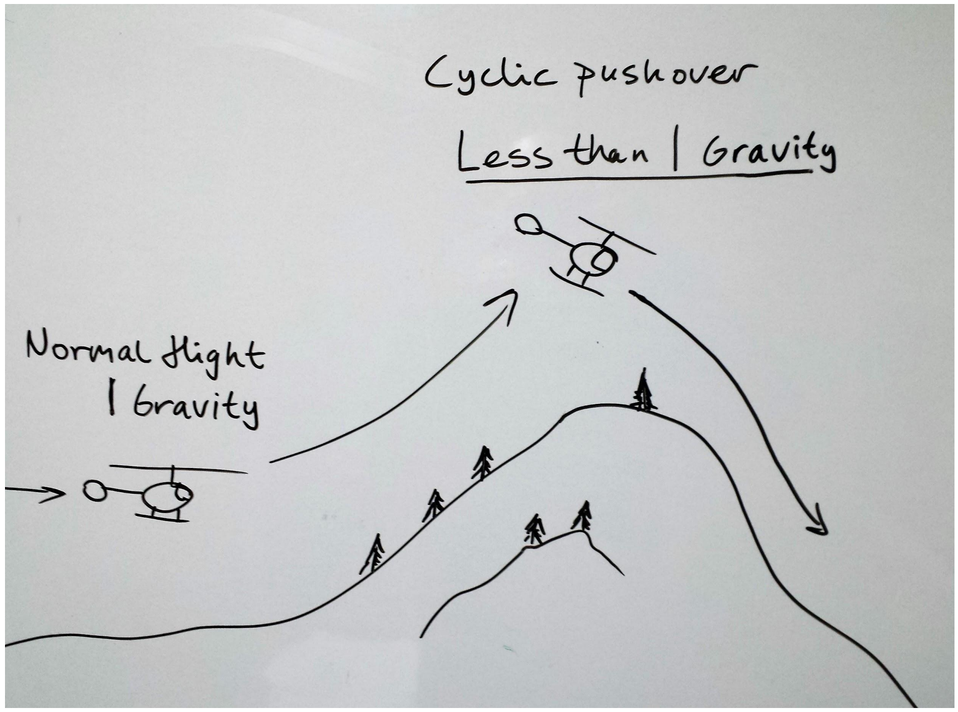
Flight training - § 2 (b) (iii):

A. Enhanced training in autorotation procedures
B. Engine rotor RPM control without the use of the governor
C. Low rotor RPM recognition and recovery
D. Effects of low "G" maneuvers and proper recovery procedures

A closer look at the awareness training

The R22 and R44 have a specific type of rotor system which comes with a couple of properties that we must be aware of in order to operate them safely.

Low "G" hazards and Mast bumping



The R22 and R44 have a semi-rigid, teetering, underslung rotor system. This type of rotor system is susceptible to a certain aerodynamic hazard that involves low G situations. Kinetic energy causes the effect of control inputs to be very strong at high speeds. If you drive along at 80 MPH in you car, and suddenly turn the steering wheel 1 inch to the right, you will be pushed quite hard to the left in your seat by the G forces. If you do the same at 10 MPH, the effect will barely be noticeable. The same holds true for a helicopter. While large or abrupt control inputs should be avoided at all times, they can be catastrophic at higher speeds.

Large, forward cyclic inputs (especially at high speeds) or strong, sudden updrafts or downdrafts can get us into the low G condition. Examples of this could be collision avoidance, trying to follow terrain or an abrupt level off from a climb using forward cyclic instead of lowering the collective.

When this happens, the helicopter is pushing up on the rotor hub instead of being suspended below it like in normal flight and the rotor and fuselage can move independently of each other. Since the tail rotor is above the Center of Gravity, it's thrust will rapidly (up to 100°/sec) roll the helicopter around the Center of Gravity to the right and at the same time yaw our nose to the left.

If the pilot instinctively tries to correct the roll with left cyclic the rotor disk tilts independently to the left without the fuselage following. Combined with the right roll this will allow the rotor blades to flap beyond their design limit which can lead to the main rotor hub contacting the rotor mast and start "bumping" back and forth. The forces involved are tremendous and can deform or sever the rotor mast, cause the main rotor blades to cut the tail boom clean off or even impact the cockpit.

<u>Avoidance</u>: we can avoid the low G condition by <u>never</u> aggressively pushing forward on the cyclic and staying away from moderate or greater turbulence. If we inadvertently encounter turbulence, we can minimize the hazard by slowing down to 60-70 KIAS (R22 Pilot's Operating Handbook (POH) section 4-8 and Safety Notice-32 (SN-32,)) minimize control inputs, leave the area of turbulence or land the helicopter.

<u>Recognition</u>: we can recognize an impending low G situation by a feeling of weightlessness.

<u>Recovery</u>: the correct recovery method is for the pilot to <u>immediately</u> reload the rotor disk (in other words, restore positive G-forces) with <u>gentle</u> aft cyclic and only then correct the roll with lateral cyclic.

Rotor RPM decay and rotor stall

The R22 and R44's rotor system is also a lightweight/low inertia rotor system. This means that since the blades have low mass their inertia is relatively low, even with Revolutions Per Minute (RPM) at 104%. If any force like drag, lift or torque acts upon the rotor system it will change its speed (RPM) or direction (Flap) faster than most other rotor systems.

Rotor RPM will increase easily, which means that we are susceptible to overspeeds (Rotor RPM exceeding 110%,) which can cause structural damage to the rotor blades and spindle bearings.

Rotor RPM will also decrease easily which can be hazardous if not recovered from. The Low RPM warning system will sound a horn and illuminate a light if Rotor RPM decrease below 97% with the collective other than in the full down position.

The correct recovery is to simultaneously and smoothly:

1. Increase throttle
   - To help the engine increase RPM
2. Lower collective
   - To decrease AoA → decrease drag → RPM increase more easily
3. If we have forward airspeed, gentle aft cyclic
   - To increase load factor → increase coning → increase RPM

If we ever allow Rotor RPM to decrease below 80% +1% per 1000 feet Density Altitude, the rotor will stall causing greatly increased drag and decreased lift. This further decreases the Rotor RPM and causes our sink rate to increase very rapidly. The combined effect of the loss of centrifugal force (which gives the rotor blades their rigidity) and the upwards rushing air eventually causes the blades to fold vertically up, and the helicopter will lose its ability to stay airborne. Below 80% +1 per 1000 there is NO RECOVERY.

Energy Management

Due to the low inertia rotor systems and how fast RPM can change in these helicopters it is very important for pilots to be able to properly manage the energy stored in the helicopter and rotor system.

Power on: Avoid large, abrupt control inputs, maintain a safe airspeed above 50 kts (except for takeoff & landing) and engine and rotor RPM inside the green arc at all times. Avoid flying in moderate, severe or extreme turbulence, and never turn off the governor except if it malfunctions or to practice for a malfunction.

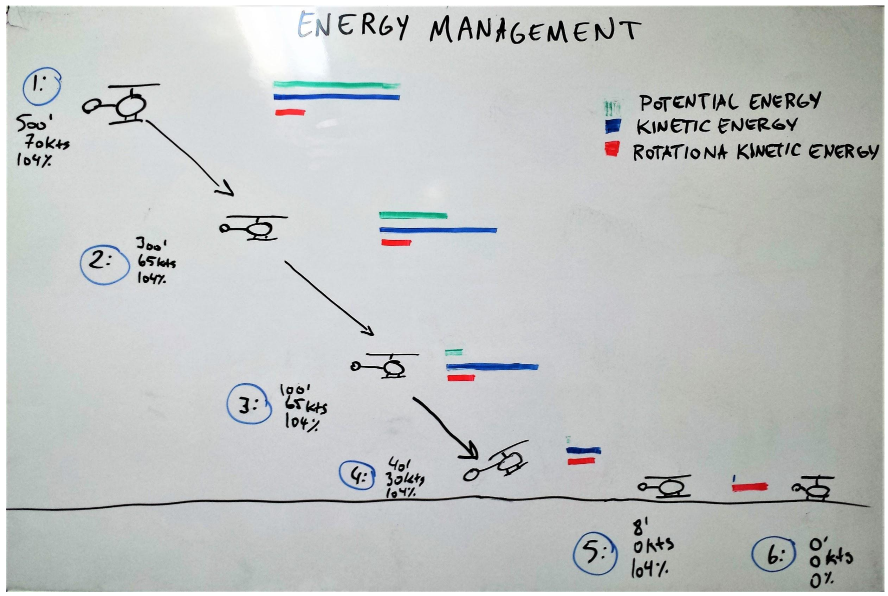
Power off: If our engine or drive system fails it no longer provides the energy to overcome rotor drag. Instead we must now use the energy stored in the helicopter in the following 3 categories:

1. Height above the ground
   - This is the potential energy stored in our vertical distance above the ground. The higher we are the more potential energy we have, since there is a greater volume of air to descend through. That upward airflow through the disk keeps the main rotor spinning.
2. Forward airspeed
   - This is the kinetic energy stored in in the forward speed of the entire helicopter. The faster we go, and the heavier we are, the more kinetic energy. Note that just like in the lift formula, velocity is squared. In other words: doubling the airspeed results in 4 times more kinetic energy.
3. Rotor RPM
   - This is the rotational kinetic energy stored in our rotor. The higher the Rotor RPM, the more rotational kinetic energy. Again, velocity is squared, so if rotor RPMs start decreasing, our rotational kinetic energy disappears quickly.

You can think of these 3 types of energy as buckets of water. If one starts leaking, we can pour water into it from either or both of the remaining two to keep it full until we are safely on the ground.

As soon as the engine or drive system fails, drag will start slowing down the rotor. We must act quickly to keep the energy in the rotor system from decreasing by immediately lowering the collective full down. This also causes our rotor thrust to decrease which initiates the descent necessary for a successful establishment of the autorotational flow. We are now continuously transferring the potential energy of our altitude into the rotational kinetic energy of the rotor.

During the glide, it is important to keep rotor RPM between 90 - 110% to avoid an overspeed or underspeed. We can do this by using the kinetic energy stored in our forward speed using the cyclic control, and by adjusting the rate at which potential energy is transferred to the rotor by using the collective control. If rotor RPM are low, and airspeed is high, we can give aft cyclic to put some of our kinetic energy into our rotor RPM. If RPM are too high and forward speed is too low, we can give forward cyclic to put the unwanted excess of energy in the rotor back into the kinetic energy of our forward speed. If both RPM and airspeed are low, we have to use more potential energy to fill them both at the same time (lower collective and forward cyclic,) which causes us to descend faster.



As we approach the ground, we must stop our descent and forward speed to avoid a hard impact. Since we are almost out of potential energy, we must use all of our kinetic energy, again, stored in the forward speed of the helicopter to keep the rotor spinning. We do this by flaring the helicopter with aft cyclic at about 40 ft. AGL (POH 3-2).

Just before touchdown at about 8 ft. AGL (POH 3-2) we use the sole remaining bucket of energy, stored in the rotational kinetic energy of our rotor, to cushion the landing by raising the collective. It is very important that we touch down with skids level and nose pointed straight ahead.

If possible, avoid the shaded areas of the height/velocity diagram to give yourself enough time and energy to make a safe landing in case of a power failure. (POH 5-11)

A closer look at the flight training

Enhanced training in autorotation procedures

If our engine fails and we correctly enter an autorotation, a good landing spot may not present itself straight ahead, perfectly aligned with our glide angle. In that case we must change something in order to safely land at the best possible landing site, preferably into a headwind.

According to Robinson's Flight Training Guide this includes:
- Use of turns
  - To change our flight path
- Use of airspeed
  - To extend or shorten our glide distance
- Use of pedals
  - To extend or shorten glide distance
- Use of sideward flight
  - To change glide distance or flight path

- Maximum glide distance configuration → Rotor RPM 90% and airspeed 75 knots
  - This allows you to glide the furthest, which is useful if there is no available landing site close by

- Minimum rate of descent configuration → Rotor RPM 90% and airspeed 53 knots
  - This gives you more time to attempt the engine restart procedure or a potentially safer landing if you don't know what's underneath you (e.g. at night)

Engine rotor RPM control without the use of the governor

There are only two reasons why we should ever fly with the governor turned off.
1. Governor malfunction (in-flight emergency)
2. To practice for a governor malfunction

There are 3 systems installed in the R22 that we can use to manipulate RPM.
1. Throttle twist grip (manual)
2. Correlator (mechanical)
3. Governor (electronic)

The throttle twist grip allows the pilot to manually increase or decrease RPM.

The correlator is a mechanical linkage that opens the butterfly valve in the carburetor when you raise the collective and closes it as you lower collective. This keeps automatically RPM in the "ballpark" and only requires minimal manual throttle adjustment from the pilot once the helicopter is airborne.

The governor is an electronic device that monitors the engine RPM with tach points in the engine right magneto to continuously and automatically adjust the throttle twist grip position to keep RPM at 104%. This provides automatic fine-tuning of RPM.

If the governor malfunctions, the pilot should turn the governor off and provide this fine-tuning of RPM by the use of the throttle twist grip. RPM will be affected both by aerodynamic forces acting on the blades as well as torque from the engine.

Low rotor RPM recognition and recovery

We practice low RPM recognition and recovery to build an automatic and correct response to decreasing RPM.

Recognition:

1. Change/reduction in noise level and/or vibrations
2. Nose left yaw due to decreasing torque
3. Low rotor RPM warning system light and horn activate below 97%

Recovery: (POH SN-10)

- Simultaneously and smoothly:
    - Increase throttle
    - Lower collective
    - Gentle aft cyclic (if in forward flight)

Effects of low "G" maneuvers and proper recovery procedures

Low "G" maneuvers are prohibited. According to the R22 POH SN-11, even highly experienced test pilots have been killed while investigating the condition.

Because of this, the low "G" maneuvers are only discussed during ground lessons and the emphasis should be on avoiding the low G condition altogether. See awareness training.

Who needs what and when do they need it?

Student pilots:

- Prior to manipulating R22 or R44 controls:
  - Awareness training [1]

- Prior to solo:
  - SFAR flight training (valid up to 90 days) [2]
  - 20 hours of dual instruction (in appropriate model) [2]
  - Awareness training - recommended

- Prior to acting as PIC (PPL checkride:)
  - SFAR flight training [3]
  - 10 hours of dual instruction
  - Awareness training - recommended

To act as PIC in R22 for pilots with helicopter rating:

- All pilots, prior to manipulating R22 controls:
  - Awareness training [1]

- Pilots with <u>less than</u> 200 hours total helicopter and 50 hours R22:
  - SFAR flight training [3]
  - 10hr dual instruction [3]
  - Annual Part 61.56 flight review in an R22 [4]

- Pilots with <u>at least</u> 200 hours total helicopter and 50 hours R22:
  - Biennial Part 61.56 flight review in an R22

To act as PIC in R44 for pilots with helicopter rating:

- All pilots, prior to manipulating R44 controls:
  - Awareness training [1]

- Pilots with <u>less than</u> 200 hours total helicopter and 50 hours R44:
  (25 R22 hours may be credited towards the 50 R44 hours)
  - SFAR flight training [3]
  - 10 hours dual instruction in a Robinson helicopter [3]
  - 5 hours dual instruction in an R44 [3]
  - Annual Part 61.56 flight review in an R44 [4]

- Pilots with <u>at least</u> 200 hours total helicopter and 50 hours R44:
  (25 R22 hours may be credited towards the 50 R44 hours)
  - Biennial Part 61.56 flight review in an R44

Flight instructors:

- 200 hours total helicopter and 50 hours R22 or R44 as appropriate[5]
  (25 R22 hours may be credited towards the 50 R44 hours)

- Demonstrates the ability to teach the awareness training and flight training[5]

- Endorsement from authorized DPE or FAA inspector for each type
  (R22 and R44)

Currency requirements:

- The recent flight experience requirements of FAR part 61.57 (3 takeoffs and landings within 90 days) must be accomplished in an R22 or R44 as appropriate

References:

- CFR Title 14 SFAR 73 to Part 61:
  - http://www.ecfr.gov/
- Helicopter Training Videos' section on SFAR 73:
  - http://www.helicoptertrainingvideos.com → videos → helicopter regulations → SFAR 73 awareness training
- Tim Tucker's video presentation on SFAR 73:
  - http://www.gyronimosystems.com/SFAR/
- Robinson Helicopter Company SN - 32 Video by Tim Tucker
  - https://www.youtube.com/watch?v=qY4Ln8Kbhr4
- R22 Flight Training Guide:
  - https://robinsonheli.com/flight-training-guide/
- R22 POH:
  - Low "G" Mast bumping:
    - Sections 2-6 and 4-15
    - Safety Tip 1
    - Safety Notices SN-11, 29 and 32
  - Low Rotor RPM:
    - Sections 3-10, 4-10, 4-15 and 7-4
    - Safety Tip 9 and 13
    - Safety Notices SN-10, 24, 29 and 34
  - Energy Management
    - Section 4-10 and 5-11

1 Required for Awareness Training endorsement
2 Required for Solo endorsement
3 Required for PIC endorsement
4 Renews PIC endorsement
5 Required for CFI endorsement

Notes