

## EXERCISE 11

### SPINNING

#### Introduction

1. In the early days of flying, stalling and spinning took a heavy toll of pilots and aircraft. This was because the causes of these two conditions of flight were not clearly understood. Also, the necessary recovery actions are the opposite of those that an inexperienced pilot would use instinctively.

2. Spinning can develop if an aircraft is not recovered promptly or correctly from a stall. An accidental spin can be caused by mishandling the aircraft's controls. The extent of mishandling required to cause an accidental spin, and the characteristics of the spin, will vary with different types of aircraft. It is difficult to cause a Firefly to enter a fully developed spin accidentally. You are not likely to enter a full spin inadvertently but you must be able to recognise and recover from it. Intentional spinning is prohibited in most front-line aircraft so it is only in training aircraft that you can experience the indications and sensations of a spin and learn to recognise the conditions of flight that are likely to induce a spin. If you recognise loss of control early, you will be able to recover at the incipient stage of a spin and minimise height loss. If you allow a full spin to develop, the height loss will be very much greater. When you know that you can recover safely and quickly from an unintentional or accidental spin, you will be confident and able to handle the aircraft close to its limit safely; this is a vital skill for an operational pilot.

#### PRINCIPLES OF FLIGHT

##### Wing Tip Stalling

3. Exercise 10 (Stalling) showed that a wing drop is one of the characteristics of a fully developed stall. This is because the stall does not usually occur simultaneously over the entire wing; one wing may stall earlier than another. This unequal stalling causes a local reduction in lift over the affected area. The unstalled wing is unaffected and the result is a tendency to roll towards the stalled wing. The extent and suddenness of the stall determines the rate of roll.

##### Autorotation

4. The fact that one wing may drop when an aircraft stalls is the basic cause of spinning. This can be seen from the graphs showing variations of  $C_L$  and  $C_D$  with the angle of attack (Fig 11.1).

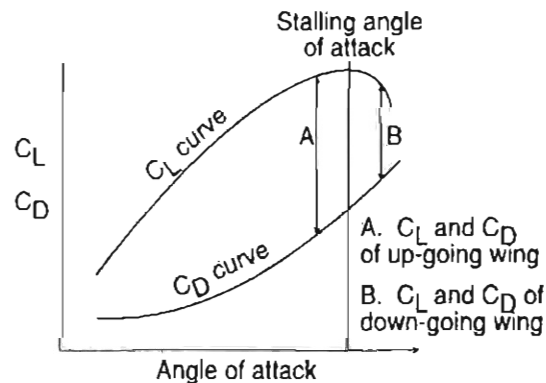


Fig 11.1 Variation of  $C_L$  and  $C_D$  curves with angle of attack

Suppose that a wing is just at the stalling angle and, therefore, at the peak of the  $C_L$  Curve. If the aircraft now rolls for some reason, the angle of attack of the down-going wing particularly at the tip, is increased to some

figure greater than the stalling angle (B in Fig 11.1), while that on the upgoing wing is reduced (A in Fig 11.1). As a result of the decrease in lift that accompanies the stall, the total lift on the down-going wing is less than that on the rising wing and so a rolling motion is set up. The  $C_D$  curve shows that, after the stall, there is a marked increase in drag, and the drag on the down-going wing is therefore higher than that on the other wing. This results in a movement that yaws the nose towards the down-going wing. The increase in drag tends to hold back the wing that is dropping, causing it to lose still more speed and lift. If this cycle is allowed to continue, it will result in a situation where the nose of the aircraft rotates automatically towards the lower wing. This is known as autorotation. The process of autorotation, if not checked, can lead to a number of complicated and unsteady manoeuvres involving motions about all three aircraft axes and these motions might, in turn, lead into a spin. To summarise, the circumstances that must prevail before an aircraft will spin are:

- a. The aircraft must be in a stalled condition.
- b. The aircraft must yaw and/or roll.

5 During the course of your flying training you will find that your aircraft will assume some unusual attitudes; whatever attitude your aircraft is in, it will not spin unless it is stalled and there is yaw and or roll present.

### **Recovery at the Incipient Stage**

6. To be effective, recovery from autorotation must be taken without delay and for the Firefly certainly before the first 360° of roll is complete. The recovery actions will need to remove any stalled condition (buffet), and stop both yaw and roll. To do this, as soon as a departure from normal flight with buffet and undemanded roll is noted, promptly centralise both control column and rudder to remove the buffet and prevent further roll. Should any buffet remain, move the control column centrally further forward until the buffet stops. The aircraft may recover from autorotation in any attitude, but once the stall buffet has stopped the ailerons may be used in the normal way to recover to wings level.

### **Definition of a Full Spin**

7. A spin is a condition of stalled flight in which the aircraft describes a spiral descent. During a spin, the aircraft is simultaneously rolling, pitching and yawing; this movement continues automatically until the pilot has carried out the recovery action effectively. As well as the normal aerodynamic forces and moments, the aircraft is subjected to inertial moments from gyroscopic cross-coupling effects.

### **Characteristics of the Spin**

8 Spinning characteristics differ greatly between aircraft types so it is not possible to generalise about the spin behaviour of all types of aircraft. Only the Firefly spin characteristics and the factors affecting them are discussed in this exercise.

9. Aircraft such as the Firefly that are cleared for spinning are said to have a normal spin. The normal spin is a smooth, settled motion in which the aircraft describes a steady, descending corkscrew path about a vertical axis, with the mean angle of the wings greater than the stalling angle (Fig 11.2). In the Firefly, in the first turn of a spin the yawing and pitching are easily identified; the nose pitches up slightly and the aircraft rolls rapidly in the direction of applied rudder. In the second and third turns, the nose drops until it is about 40° below the horizon. The rate of rotation is about 2 ½ seconds per turn. Thereafter, the spin remains steady.

### **Factors Affecting the Spin Characteristics**

10. The factors affecting the spin characteristics of an aircraft are as follows:

- a. **The aircraft's mass and distribution of mass.** The mass and it's distribution will have a considerable affect on the inertial forces on a spinning aircraft. For example, if the mass in the wings is increased by fuel or other stores then the inertial forces in roll and yaw will be greater and will affect the

rate of rotation of the spin and possibly the recovery. Similarly, an aft C of G may cause the spin attitude to flatten making the recovery time longer.

b. **The position of the flying controls.** The effect of aileron on the spin depends on the aircraft's mass distribution. On some types, use of aileron can dampen spin oscillations or aid recovery, but because mass distribution may change during flight, the effect of aileron on the spin is unreliable. In most aircraft cleared for deliberate spinning, including the Firefly, the ailerons must be held central. The position of the rudder and elevators may also affect the spin. Normally, for intentional spinning, full rudder in the direction of spin and full up elevator deflection should be applied and held on until recovery is initiated; this is known as "full pro-spin control".

c. **The aircraft attitude and flight path during the entry to the spin.** Normally, entry to a deliberate spin follows a predictable pattern and even at extreme attitudes, if an inadvertent spin is induced, an aircraft will fall into an erect spin. If entry occurs at high speed, the aircraft may follow the original flightpath for a short time as it autorotates before dropping into a full spin.

d. **Use of power.** If power is held on during a spin, the rate of descent will increase as will the height needed for recovery. The throttle must definitely be closed for recovery.

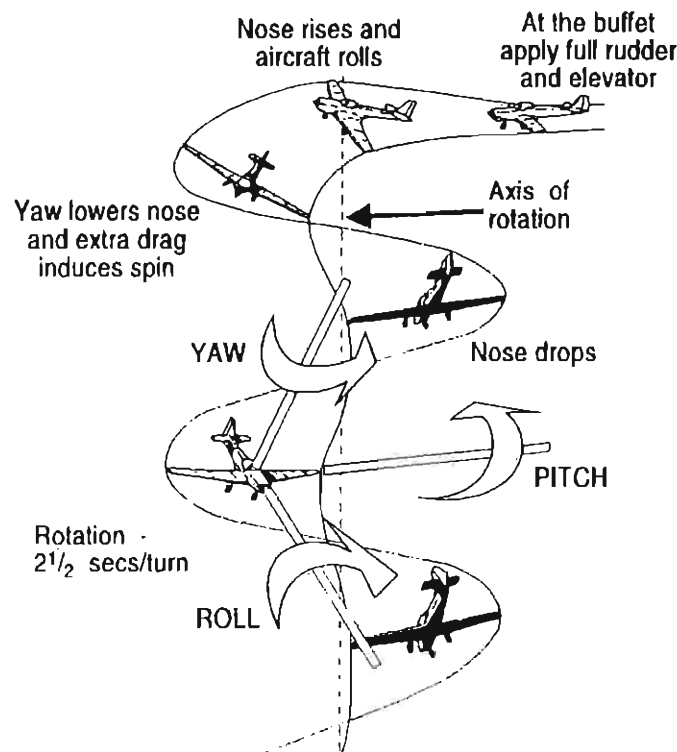


Fig 11.2 Normal Spin

### Full Spin Recovery

11. **Height awareness.** A considerable amount of height will be lost in the time that it takes to recover to straight and level flight from a full spin. Another effect of this high rate of descent is to increase the height required for a successful abandonment from a spinning Firefly. Intentional spins, therefore, are always entered from a height which will ensure that the aircraft will normally recover at a safe height, or could be abandoned successfully. You will see how the various heights for intentional spins are calculated in para 19. It is vital to develop an instinctive awareness of height during spinning, and your first action in any spin must be to ensure that you have sufficient height to complete the recovery or to decide whether abandoning the aircraft would be more appropriate.

12. **Recovery actions.** Assuming the height for recovery is sufficient, the recovery actions must be to stop the rotation and unstall the wings so that the aircraft can be levelled out from the high rate of descent with the minimum height loss. Each aircraft has its own specific spin recovery drill quoted in its Aircrew Manual. In all cases this drill must be followed implicitly. The Firefly will recover from a spin if positive and correct recovery action is taken as shown in the Aircrew Manual. Briefly, the drill is to :

Check height

Close throttle

Check flaps locked up

Check direction of yaw as indicated by the turn needle

Apply and maintain full rudder to oppose yaw

Move the control column centrally forward, smoothly and firmly until the spin stops

Centralise the rudder when spin stops

Level the wings and pull out of the dive

13. **Use of the turn needle.** For a deliberate spin, the direction of rotation will be known; this may not be so obvious if the spin is entered accidentally. The turn needle will always give the correct indication of the direction of spin rotation and so confirm which way to apply full rudder for recovery - if the turn needle points to the left apply and hold full right rudder.

14. **Signs of recovery.** The Firefly will normally recover from a spin within one or two turns following the correct recovery drill. The paradox of the recovery is that as the actions begin to take effect, the nose attitude will steepen and the rate of rotation increase. These signs confirm that recovery is imminent and mean that the full anti-spin controls must continue to be applied in the correct way until the spin stops.

## Physiological Effects

15. **Disorientation.** During your first spinning lessons in the Firefly, you might become disorientated. This is not unusual and, to reduce the chances of your becoming disorientated, your instructor will carry out only short spins at first. Also, he will spin only when there is a well-defined horizon and when ground features are easily seen. You can help to overcome the problem of disorientation if you avoid rapid head movements during a spin and look through the windscreen over the nose of the aircraft, toward the horizon.

16. **g threshold.** During a spin, the pilot's g threshold might be lowered; unless you prepare yourself, you might find that even relatively low-g pull-outs from a spin recovery dive bring you to the verge of a blackout.

17. **Air sickness.** It is not unusual for students to feel air sick when they are first introduced to spinning. Do not worry; this feeling is quite common, even among experienced pilots who have not been subject to spinning for some time and it rarely persists. Tell your instructor immediately if you continue to feel ill; he can stop the exercise and return to it another time.

## AIRMANSHIP

### Safety Checks

18. Before you practise spinning, carry out the HASELL checks. For spinning, these checks are similar to those for stalling; the main differences are the safety height calculations, additional checks for weather considerations and the lookout turn, which are explained in the following paragraphs.

19. **Height.** Before spinning, you must calculate the minimum abandonment height (MAH), the minimum height to commence recovery (MHCR) and the minimum entry height (MEH):

- a. **MAH.** The minimum height for abandoning a Firefly in a spin is 3000 ft agl. In practice, since the altimeter will be set at 1013 mb, we use transition level plus the height of the ground. To ensure that you will be out of the aircraft by a safe height the abandoning drill will need to be initiated at MAH.

b. **MHCR.** MHCR is calculated by adding 2000 ft to MAH or, if spinning directly above cloud, 2000 ft above the cloud top, whichever is the higher.

c. **MEH.** The Firefly loses approximately 250 ft per turn in a spin; therefore MEH is calculated by adding an allowance of 250 ft per turn to MHCR.

20. **Weather conditions.** To prevent disorientation, you should spin only when there is a well-defined horizon and the canopy is clear of mist and ice. You should also have a clear 360° horizon and cloud irregularities that make any yaw and roll of the aircraft readily apparent.

21. **Lookout turn.** A clearing lookout turn is absolutely essential before spinning because full control cannot be regained instantly while the aircraft is in the spin. The lookout turn must be through at least 360° during which the terrain below should be assessed and the airspace down through which the aircraft will descend must be checked to ensure that it will remain clear of all other aircraft during the spin recovery.

### **Recovery Instructions**

22. The aircraft can lose height quite quickly during a spin. It is important to take recovery action immediately when told to do so by your instructor. To prevent any misunderstanding your instructor will say “Recover now”. You must acknowledge by saying “Recovering now, Sir”. If you do not acknowledge your instructor’s order in this way, he will assume that you have not heard him and he will take control of the aircraft and carry out the recovery.

### **AIR EXERCISE**

23. The aim of the exercise is to accustom you to spinning and to teach you how to enter, maintain and recover from a spin. The exercise is in three sorties. The first is concerned with learning the academic spin entry from level flight and how to recognise and recover from a full spin. The second deals with recognition and recovery from an incipient spin. Finally, on a later GH sortie, consideration will be given to spinning from manoeuvres.

### **AIM - SPINNING 1**

24. The aim of this exercise is to recognise and recover from a full spin with the minimum height loss.

### **AIR EXERCISE - SPINNING 1**

25. **Flying Controls - central position.** Before take-off, visually centralise the flying control surfaces and reconfirm the position of the cockpit controls. This is where to place the controls, regardless of trim forces, to guarantee an incipient spin recovery.

26. **45° bank turns.** Prior to commencing the first spinning exercise you will be taught 45° bank turns (refer to exercise 15 part 1). You will subsequently fly the clearing lookout turn at 45° angle of bank.

### **Demonstration Spin**

27. You will have been shown a fully-developed spin on a previous sortie. You will have noted that having induced the spin, there is no problem in recovery.

### **Spins from Level Flight**

28. To save time, all the pre-spinning checks, except for the clearing turn, can be carried out during the climb through the last 1000 ft or so before levelling off at spinning height. Carry out your clearing turn through 360° using 45° AOB, paying particular attention to the airspace below.

### **Spin Entry**

29. Roll out of the clearing turn pointing towards a clear area, close the throttle and maintain straight and level. Continue trimming to 70 kts. Your instructor will now teach you how to enter the spin. To achieve a positive entry to a spin, we induce the aircraft to yaw at a speed slightly above the stall. At 60 kts, with both

hands on the control column, firmly apply full rudder in the direction you wish to spin, and at the same time move the control column fully back, keeping the ailerons neutral. Make sure that you obtain full control deflection to ensure that the aircraft enters a normal, erect spin. Use both hands on the control column to help you to keep the ailerons neutral and the control column fully back. As the controls are applied, the nose rises and the aircraft rolls sharply in the direction of spin. The nose then drops and settles into a steady state of rotation in quite a steep attitude.

### **Maintaining the Spin**

30. The spin is maintained by keeping the controls in the full pro-spin position as described previously. Make sure that you retain full rudder and full up elevator and that you keep the ailerons neutral. During the exercise, your instructor will point out several features. When he does so, try to look by moving your eyes rather than your head; in this way, you will reduce any feeling of disorientation. For the same reason, when looking out, avoid looking at the ground immediately over the nose of the aircraft and look up instead towards the horizon.

### **Recognition of the Full Spin**

31. The indications that an aircraft is in a fully developed spin are:

External indications:

- a. The nose attitude will be low.
- b. The rate of rotation will be high.

Internal indications:

- a. The altimeter and VSI will show a high rate of descent.
- b. The turn needle will show full deflection in the direction of the spin.
- c. The airspeed will remain at a low constant value.

### **Full Spin Recovery**

32. You will always recover from a spin on the command "recover now". The Firefly spin recovery can be summarised as follows:

- a. Check height.
- b. Check that the throttle is closed.
- c. Check that flaps are locked up.
- d. Check direction of yaw as indicated by turn needle.
- e. Apply and maintain full rudder to oppose yaw.
- f. Move the control column smoothly and firmly forward until the spin stops, ensuring that the ailerons are neutral throughout.
- g. Centralise the rudder when spin stops.
- h. Level the wings with aileron and ease out of the dive, bracing yourself against any g effects.
- i. Apply full power as the nose reaches the horizon and climb away.

33. You will first practise spinning to the left, however, when your instructor is satisfied that you can recover from the full spin he will teach you the entry and recovery from a spin to the right. Finally, on a separate sortie, he will teach you incipient spin recognition and recovery off manoeuvre.

34. If spin recovery action is unsuccessful, it is vital that you re-check height and if time permits, confirm your actions, otherwise you must start the abandonment drill by MAH.

### **AIM - SPINNING 2**

35. The aim of this exercise is to recognise and recover from an incipient spin with minimum loss of height.

## AIR EXERCISE - SPINNING 2

36. **Revision.** On this exercise you will revise 45° bank turns and then your instructor will ask you to climb to a suitable height and complete the HASELL checks.

### Recovery at Incipient Stage

37. In the stalling exercise, you were taught that a recovery from a stall in the incipient stage results in a quicker recovery and less height lost. In the same way, we can recover more rapidly from a spin if we catch it during the incipient stage. The terms 'autorotation', 'flick' and 'departure' in connection with spinning all mean the same thing, the incipient stage of a spin. Because a spin is caused by yaw when stalled, mishandling the aircraft at high angles of attack, for example during aerobatics, might cause it to spin. Between the initial stage and the fully developed stage, the aircraft will start to roll and it is this UNDEMANDED roll that marks the point of departure. Only the first 360° of roll or half turn of the spin can be considered incipient. If you spin accidentally, you should always aim to recover at this stage. Your instructor will teach you how to recognise the incipient spin and how to recover from it. The recovery action is:

- a. Centralise the controls promptly and firmly.
- b. When rotation stops, look for the horizon and roll the shortest way to wings level. If the nose is above or near the horizon, apply full power and level the wings. If the nose is well below the horizon, close the throttle, level the wings, ease out of the dive, apply full power as the nose reaches the horizon.

38. If the spin has fully developed or the incipient recovery does not work, check the height and, if it is sufficient, your instructor will use the Firefly spin recovery drill.

**Note:** After unsuccessful or late incipient spin recovery action, the aircraft is more likely to enter an unusual spin. Do not allow the aircraft to stabilise in a fully-developed spin with power applied. Close the throttle immediately if the aircraft fails to recover from an incipient spin.

### Recognition of an Incipient Spin

39. In the above sequence, the application of full up elevator and rudder stalled and yawed the aeroplane at the same time. It then experienced undemanded roll in the stall as it departed from normal flight, and autorotated into an incipient spin. It is possible to get into an incipient spin, however, without these deliberate control inputs. You will see this as your instructor flies a series of mishandled manoeuvres at low speed and in some aerobatics. You will learn that an aeroplane will depart from normal flight and enter an incipient spin, at any airspeed or attitude, if the following happen together:

**The aircraft stalls (there is heavy buffet) and there is undemanded roll.**

This undemanded roll indicates departure from normal flight and can be recognised by the aircraft not responding correctly to the ailerons. Undemanded roll may be recognised if the aeroplane:

- a. Rolls even though the ailerons remain neutral.
- b. Rolls in the opposite direction to the applied aileron.
- c. Rolls slower or faster than the selected amount of aileron demands.
- d. Does not roll when aileron is applied.

### Conclusion

40. Prompt recognition of an incipient spin will allow timely recovery to prevent an aeroplane entering a full spin. However, it would be best not to enter an incipient spin at all. This applies particularly near the ground where the height lost in recovery would be unacceptable. In the circuit, for example, when turning onto finals monitor the attitude and balance carefully and do not pull into the buffet.

**FLY IN BALANCE AND DO NOT PULL INTO THE BUFFET**

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