DOCUMENT

GSM-G-CPL.002

DOCUMENT TITLE

AERODYNAMICS 1

CHAPTER 11– THE SPIN

Version 1.2

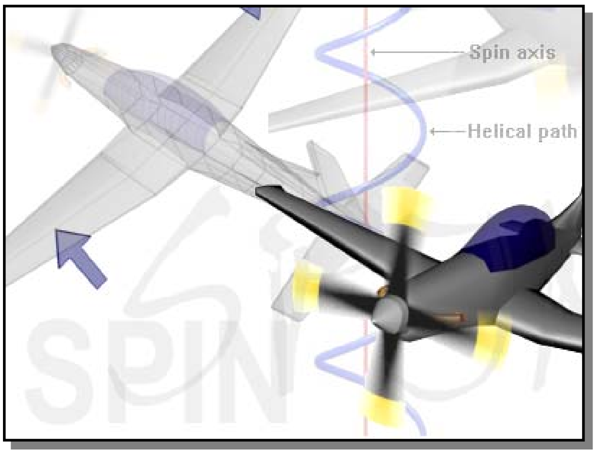
October 2013

CONTENTS .... PAGE

AN INTRODUCTION TO THE SPIN

INTRODUCTION

In the early days of aviation the spin was one of the most feared manoeuvres. This was due to the fact that the early aviators did not understand the mechanics of the spin.

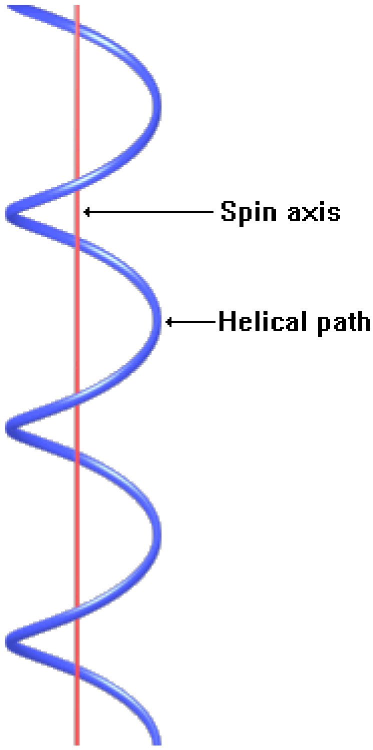


As the science of aeronautics grew so the understanding of the spin also improved, which means that the modern day aviator need have no apprehension about spinning an aircraft.

Spinning is a complicated subject to analyse in detail. It is also a subject that is difficult to make generalisations about.

PHASES OF THE SPIN

The spin is defined as a condition of stalled flight in which the aircraft describes a **helical descent**, simultaneously rolling, pitching and yawing.



The important difference between the spin and a spiral dive is the fact that the spin is a stalled condition, meaning that the angle of attack in the spin will be much higher than what it would be in the spiral dive.

It also means that the airspeed during the spin will be much lower than during the spiral dive.

Both manoeuvres follow a helical descent path.

The spin manoeuvre can be divided into 3 phases:

- The incipient spin.
- The steady (fully developed) spin.
- The recovery.

THE INCIPIENT SPIN

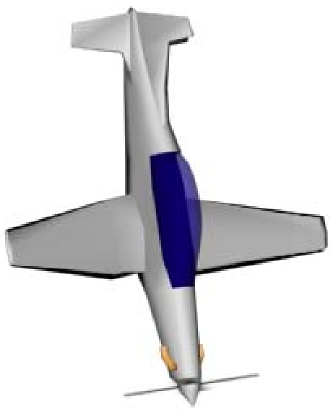
A necessary requirement of a spin is the aerodynamic phenomenon known as autorotation. This autorotation leads to an unsteady manoeuvre that will be a combination of:

- The ballistic path of the aircraft that is dependent on the entry attitude.
- The increasing angular velocity generated by the autorotative rolling moment and the drag induced yawing moment.

THE STEADY SPIN

The incipient stage may continue for some 2 to 6 turns after which the aircraft will settle into a steady rate of rotation and descent. It is these two factors that define the stable spin.

During this phase the aircraft will experience some sideslip and will be rotating around all 3 axes.



THE RECOVERY FROM THE SPIN

The recovery is initiated by the pilot by an action aimed at first opposing the autorotation and then to reduce the angle of attack so as to unstall the wings.

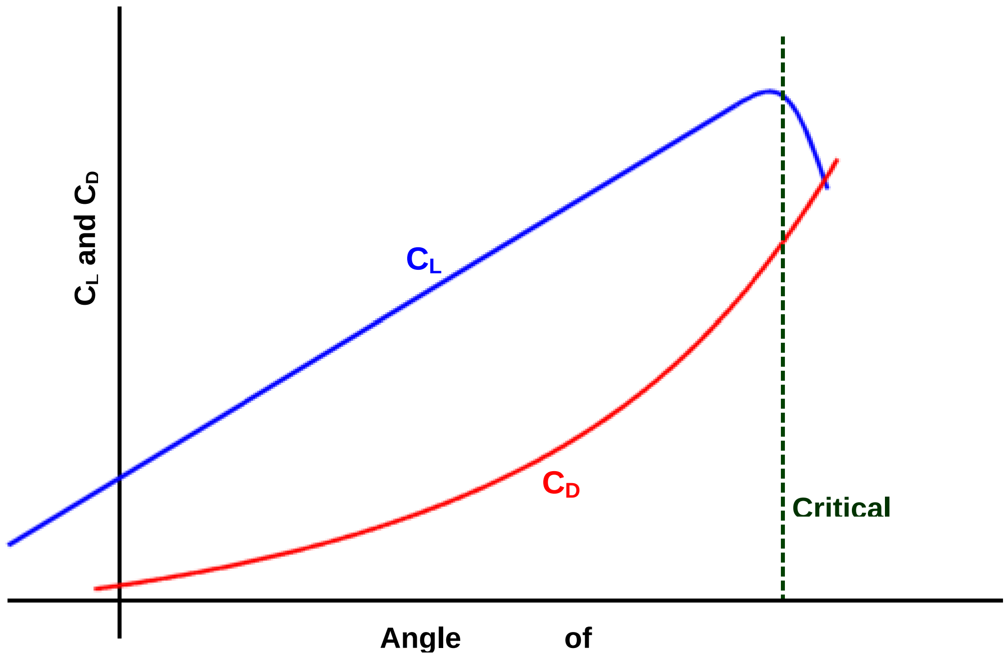
AUTOROTATION

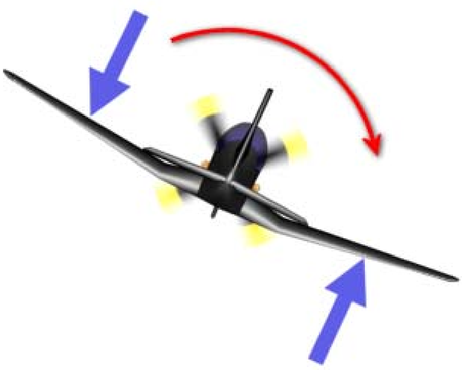
With reference to Drag, the value of the Coefficient of Drag (**C_D**) increases as the angle of attack increases.

Also, the value of the Coefficient of Lift (**C_L**) increases as angle of attack increases.

Note: At the Critical Angle of Attack, C_L will start to rapidly decrease (Aircraft is stalled).

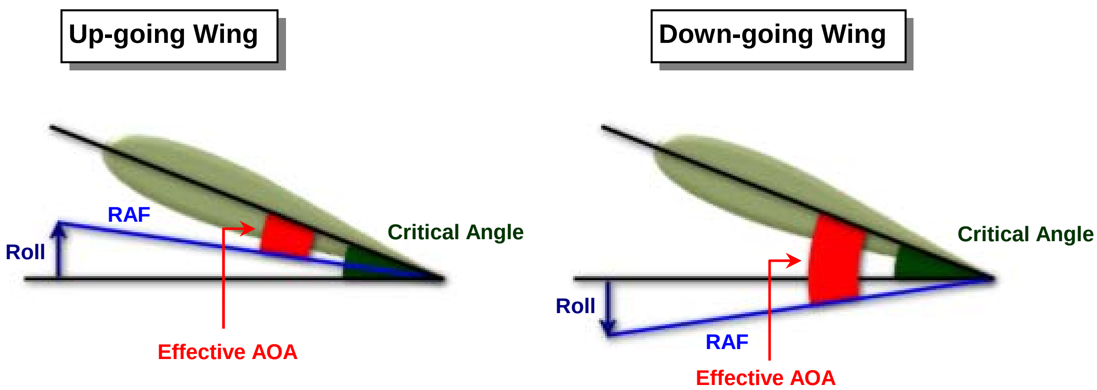
If the C_L and C_D curves are represented together it will look as indicated below:



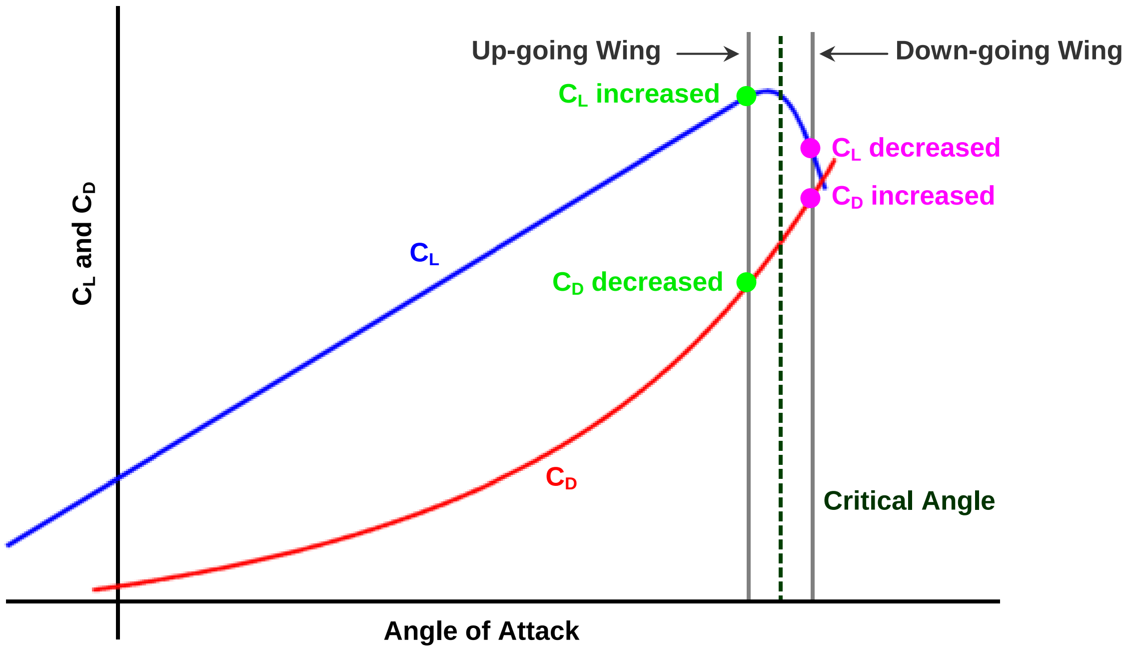


If the stalled aircraft <u>starts to roll</u>, there will be a component of airflow striking the down-going wing from underneath and a component striking the up-going wing from above.

While the **critical angle** remains unchanged, the up-going wing experiences a reduction and the down-going wing an increase in **effective angle of attack** due to the roll (***damping in roll in unstalled wing***).



The difference in effective angle of attack between the rising and down-going wing can be shown on the combined C_L and C_D graph.



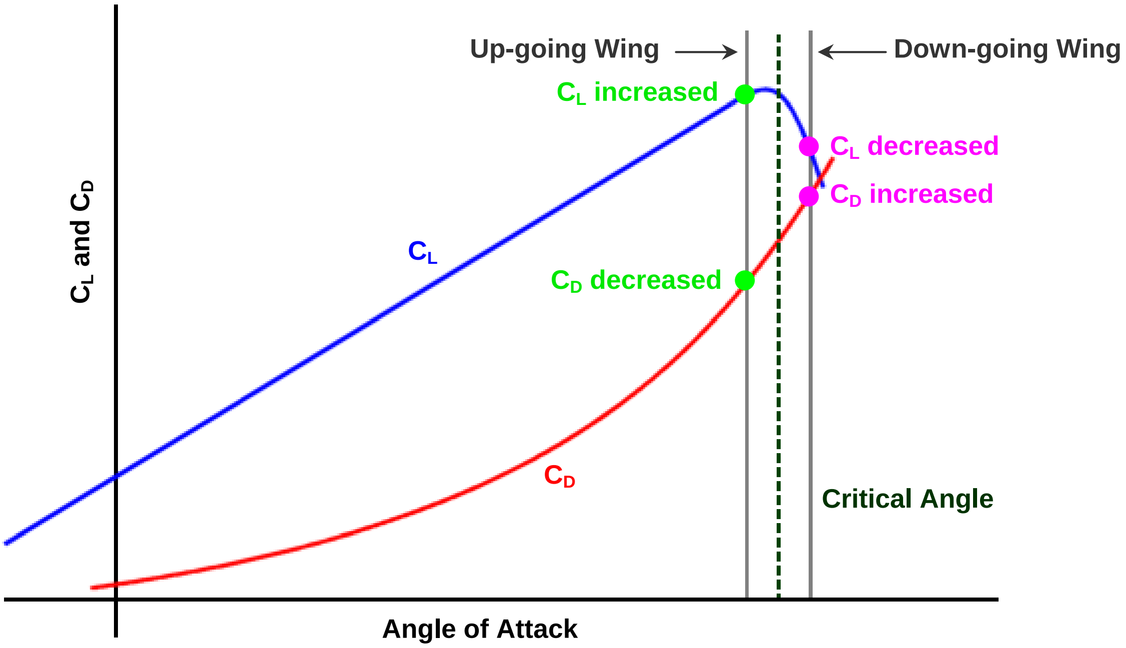
Due to the damping in roll effect, increase in angle of attack on the down-going wing, **decreases the C_L and increases the C_D**.

On the up-going wing, the decrease in angle of attack due to damping in roll **increases the C_L and decreases C_D**.

Since the up-going wing has a **greater value of C_L** the aircraft will tend to roll towards the down-going wing. Thus the roll that was started at the stall will be aggravated (the roll continuing automatically).

Thus the "damping in roll" effect at lower angles of incidence is reversed at or past the critical angle of attack.

When the C_D values of the wings are compared it is clear that the up-going wing has a smaller value of C_D and thus less drag.



Taking this difference in drag into account, it is apparent that the aircraft will yaw towards the down-going wing.

The secondary effect of the yaw is a roll towards the down-going wing that aggravates the roll that was started at the stall.

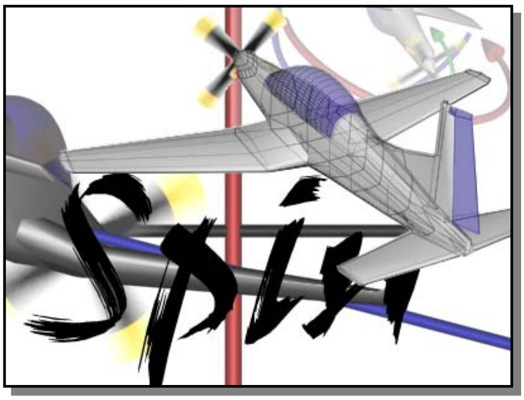
As with the roll, the yaw and it's associated roll continues automatically once it has started.

IT IS FOR THIS REASON THAT IT IS CALLED AUTOROTATION.

THE SPIN RECOVERY

INTRODUCTION

The recovery from the spin is certainly an important phase of the spin manoeuvre.



An understanding of the entry into the spin as well as the steady state of the spin is also important, but when all is said and done it is the recovery from the spin that is the most critical for the occupants of the aircraft.

EFFECT OF CONTROLS

When the overall effects of the inertial and aerodynamic moments in a spin are considered, it is found that there is a **pro-spin** rolling moment and an **anti-spin** yawing moment.

The recovery from the spin is aimed at stopping the rotation by reducing the pro-spin rolling moment and/or increasing the anti-spin yawing moment.

The yawing moment is the most important, but because of the cross coupling between motions around all three axes, the rudder may not be the only control to reduce the yaw in the spin.

Once the rotation has stopped, the angle of attack is reduced to unstall the wings. The aircraft is then considered to be recovered from the

Throughout the history of aviation experience has shown the basic control inputs to recover from the spin to be the following:

- **Power-off.**
- **Centralize Controls (Elivator and Airleron).**
- **Smoothly apply opposite Rudder.**

This sequence of control inputs is vitally important, should you ever have to recover from an intended or inadvertent spin.

The rudder is normally the primary control, but because of the design of modern aircraft, aileron deflections might also become important during the recovery.
In a spin, all the controls result in movement in a normal sense, even though the wing is stalled.