WAMASC Newsletter

October 2019

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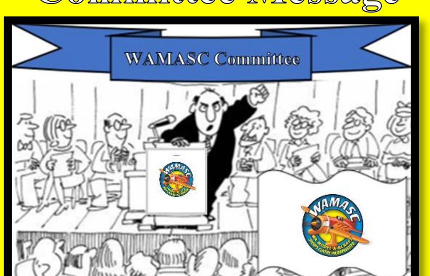
Committee Message



*should any individual have anything at all they would like to contribute, share or add to this newsletter, please feel free to contact the editor through the **Club Secretary** via ✉ secretary@wamasc.com.au – enjoy*

NEWSLETTER RE-START

The **WAMASC Newsletter** fell by the wayside circa September 2017.

That said we are now giving it a re-start, and another try. This Newsletter will be reborn as a normal monthly fixture and consist of all things aeronautical and used to pass on information as the requirement arises.

RC Aeromodelling is a wonderful environment that brings many of us together through the week and on weekends to socialise and chew the fat. All things are connected and hopefully no matter what level you are you will enjoy the smattering of Aviation articles thrown in to wet the whistle.

This Newsletter is your Newsletter, for you, and a lot of effort goes into it each month. It is done so on a completely voluntary basis and level and you are asked that if you have anything that you wish to contribute – whether a thought, ideas etc. please come forward and contact the Secretary through the mail link provided atop of the page.

AERONAUTICAL SURGE & STALL

To restart the WAMASC Newsletter I thought we would cover the topic(s) of **Surge** and **Stall** with good reason. It may sound strange to talk about jet engines with regard to our sport of aeromodelling; but with an understanding of what can happen in a jet engine makes it easier and pertinent to what can happen with a **propeller**.

So, what are these two (2) strange phenomena that can occur in a jet engine, on a wing, or for that matter – a propeller?

'**Surge & Stall**' are two totally different entities (**Surge** (**Axi-Symmetric Stall**, more commonly known as **Compressor Surge**; or **Pressure Surge**) and **Stall** (commonly referred to as **Rotating Stall**)).

We will deal mainly with Compressor Stall (**Stall**) as this phenomenon can and will occur on occasion in RC model aircraft Jet engines; the same phenomenon also effecting propeller(s) and wings. **Surge**, a different animal, can only occur when RAM air exceeds MACH 1 and is the reason air is not allowed to enter an engine intake above the speed of sound regardless of aircraft speed – it is the same reason and principle why a propeller will stop pushing air should any part of it exceed MACH 1.

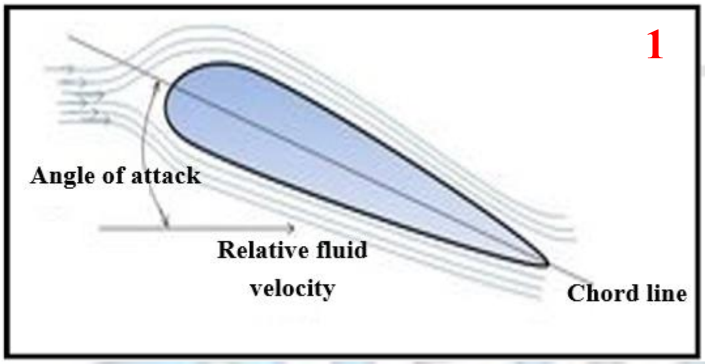
A **compressor stall** is a local disruption of the airflow in a gas turbine or turbocharger compressor. It is *related* to **compressor surge** which is the complete disruption of airflow through the compressor. **Stalls** range in severity from a momentary power drop (occurring so quickly that it barely registers on engine instrumentation) to a complete and total loss of compression (**Surge**) necessitating a reduction in the fuel flow to the engine.

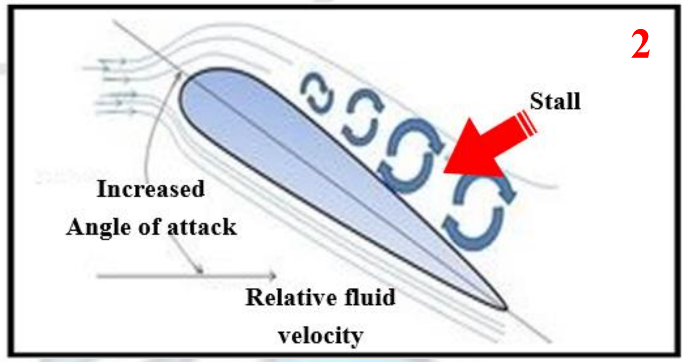
Surge and **Stall** occurs mainly in a **jet engine compressor** when a large volume of air entering into the inlet (intake) enters at a speed that causes air de-laminar flow and/or separation on the compressor blades. This is the very same effect that can occur on any lift cross sectional aerofoil whether it be a propeller, turbine, compressor, or wing.

An aircraft does not have to be travelling fast to cause a **Surge** or **Stall** condition.

A compressor blade, aircraft wing or any propeller that exceeds MACH 1 will result in same phenomena; **Surge** normally causing catastrophic damage. Indeed, the same condition, especially **Stall**, may occur in RC model aircraft propellers when over revving.

Surging and **Stalling** both lead to unstable flow in compressors and to understand the concept behind **Surging** and **Stalling**, we should once again revisit the concept of airflow over an aerofoil.





An aerofoil will stall when the airflow completely separates from its top (**Low Pressure**) side.

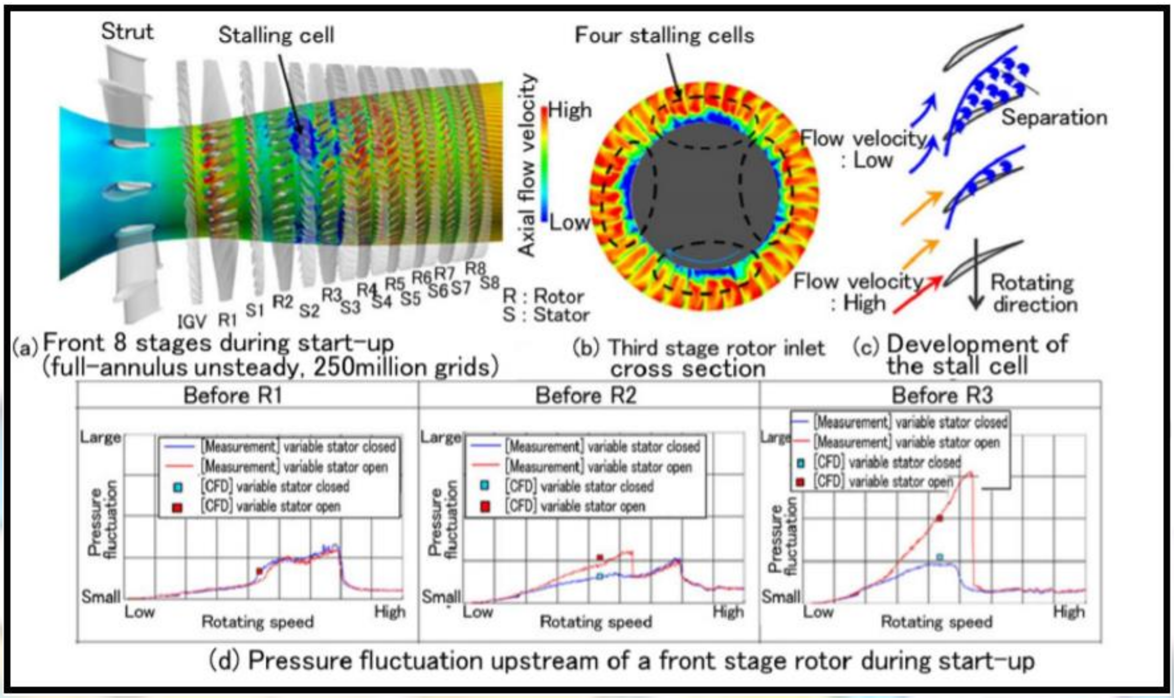
Be aware that these **High** and **Low**-pressure areas will also invert should airflow exceed the speed of sound **(343.2m/Second or 768MPH (1236Km/h) measured in dry air at sea level @ 20 °C (68 °F**). The speed of sound will vary with altitude, due to air density, and ambient t°. I once again reiterate that this is the reason RAM air is not allowed to enter an engine intake, or engine, above the speed of sound when that aircraft is operating at high speed above MACH 1. The RAM air is slowed down below MACH 1 via the use of convergent/divergent ducting, dump doors, splitter plates and venturi effect regardless of aircraft speed.

Note: I will speak about **Movable Plugs** (**Mouse**), **Convergent** and **Divergent Ducting**, **Splitter Plates**, and other methods of slowing airflow into an engine in a later edition.

The pictured blade on the previous page in diagrams **1** and **2** depict airflow commencing from the LE (Leading Edge) across the top of the blade and progressing along its width past the TE (Trailing Edge). Airflow having to travel further on the top side of the aerofoil is initially accelerated causing a reduced pressure gradient (exactly the same as a lift wing). As the flow reaches the maximum thickness of the aerofoil, it starts to slow down, causing pressure to increase, or a positive pressure gradient starts to occur. This pressure gradient is unstable as the airflow is still positive (LE towards TE). This unstable condition forces a flow separation - there is reverse flow over the aerofoil surface past the separation point. If the angle of attack of the aerofoil increases, this separation point will move forward towards the LE, making the flow separation area bigger. It will come to a point that the whole flow over the aerofoil separates, starting from the LE. This condition is called **Stall**.

There are two (2) types of compressors - **Axial Flow** and **Centrifugal**. Stall being more prevalent in the space saving design of the Centrifugal type. A **Compressor Stall** occurs when the pressure of air entering the engine drops below the pressure in the compressor, or the air within the compressor drops momentarily as a result of stalling air (disruption in air pressure (separation)). When this happens, the compressed air expands and travels toward the area of less pressure (toward the front and out the back). This is only partial compression loss due to separation.

In an **Axial Flow** compressor propagation of the instability around the flow path annulus is driven by stall cell blockage causing an incidence spike on the adjacent blade. The adjacent blade stalls as a result of this incidence spike, thus causing stall cell "**rotation**" around the rotor.



This can be related to some of the air being bypassed around the engine core, and some entering the core. Air that enters the core is compressed considerably in stages (compressed more and more as air travels toward the back) before it is mixed with fuel, ignites, and expands out the rear of the engine.

Stall in an engine is acceptable to a point. When a compressor stalls momentarily it may often go unnoticed. It may be heard as a loud bang requiring no further action. The worst-case scenario would be the requirement for an engine re-start. A compressor stall often will correct itself as soon as the flow of air in the engine is restored. Quite often the simplest corrective action by the pilot is to reduce engine power until the engine stabilizes.

Compressor **Stalls** and **Surges** where most prominent in older jet engines; however, with the advent of CAD (Computer Aided Design) technology, improved engine design and understanding, this problem has virtually vanished in the modern jet engine.

That said it has not vanished and **Surge** in an engine is something else - it occurs when the compressor has a complete and total loss of compression with the resultant effect sometimes catastrophic (complete mechanical failure) and is to be avoided at all costs. **Surging** is the complete breakdown of steady through flow, affecting the whole machine, in other words, when stalling takes place on all the blades simultaneously. This leads to choking of the flow. Sometimes even **reversal** of the flow may take place. Heavy vibrations also occur which are not conducive to an engine remaining intact.

Note: In a high-pressure ratio multistage compressor, the axial velocity is already relatively small in the higher-pressure stages on account of high densities. In such stages a small deviation from the design point causes the incidence to exceed its stalling value and stall cells first appear near the hub and tip regions. At very low flow rates they grow larger and affect the entire blade height resulting in a significant reduction in delivery pressure.

The incidence of **Stalling** or **Surging** may be increased dramatically from imbalance or missing blades, FOD (Foreign Object Damage) caused through the ingestion of sand, dirt etc. which causes erosion thus lowering the

Surge line. Dirt build-up in the compressor and wear that increases compressor tip clearances or seal leakages all tend to raise the operating line.

ORIGIN'S

Let's talk aircraft design and explore what gave rise to some extraordinary innovative thought processes' that led to extremely unique design concepts and seeds of thought born out of absolute necessity. The story behind many an idea is completely mind blowing and extremely remarkable. In particular I will begin by rewinding the clock back to a time prior to WWII and discuss the **Hawker Hurricane** and **Supermarine Spitfire**. The Spitfire is an aircraft that has etched itself into the very psyche of those who have fallen in love with it; there is, after all, nothing that supercharges the requirement and need for design innovation than a war.

The origin of the **Spitfire** was of course born out of R J MITCHELL's experience with the **Schneider Trophy** or Cup. He was into racing Seaplanes from one pylon to another (also the origin of pylon racing). That's right the Spitfire started off wearing pontoons as a float plane (the reason **Supermarine** is in her name). Her infancy and prelude to evolution is quite evident in the picture below.

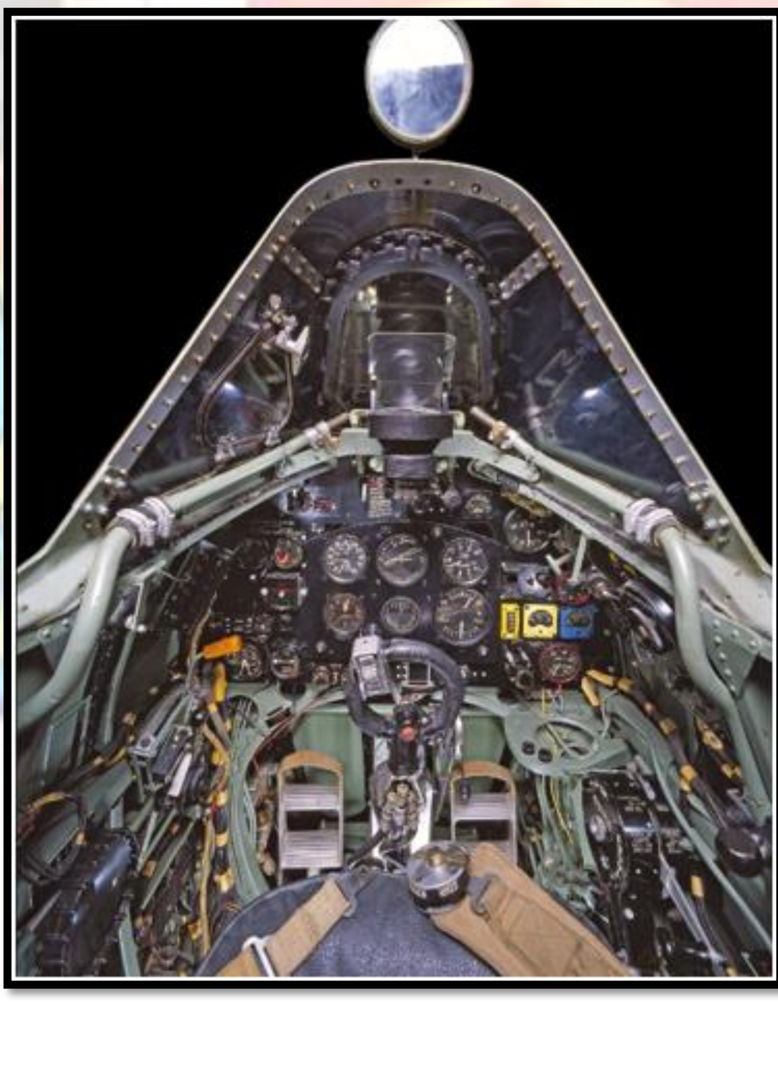
Unfortunately, from those humble beginnings it is easy to see where some engineering faux pas' have been made and note the reasons why. For instance, removing those pontoons, placing and fitting an MLG (Main Landing Gear) was always going to be a problem.

The MLG undercarriage system had to be attached to the strongest integral structure of the aircraft which was just forward of the aircraft's CoG (Centre of Gravity). This unfortunately caused it to be very close together - the wheels of the aircraft on retraction had to travel outward and disappear into the narrowing chord of the wing. This problem was further exacerbated due to minor avionics and munitions storage requirement(s).

The subsequent narrow footprint of the Spitfire's MLG meant that stability in landing and take-off roles was at an absolute premium with many a novice pilot coming to grief – and there were many.

Furthermore, due to the MLG only being slightly forward of the aircrafts CoG the aircraft could not be started without first placing the elevator in full scale upward deflection to negate the aircraft nosing down and forward beating itself into submission as it destroyed itself with its own propeller. Ground handling and taxiing was only achieved with maintenance crew having to sit on the aircraft's empennage acting as counterweights.

Another problematic flaw was the fitment and positioning of the manual hand-pump for the operation of the hydraulic undercarriage which was an absolute delight to operate - not. On failure to retract, which was often, pilots had to pump the undercarriage up with their right hand while simultaneously trying to keep the Spitfire controlled using their left hand on the control column.



The Throttle was fitted similarly adjacent in position on the left or port side of the aircraft in close proximity to a protruding fuselage stiffening rib. Like the manual hand-pump for operating the hydraulic undercarriage both items when operated in haste often led to a condition known as "Spitfire knuckle" where pilots skinned their hand on the side of the cockpit.

Now let’s talk about Engine cut out problems – not something you really want in an aircraft. The early versions of the Rolls-Royce Merlin engine came equipped with a SU carburettor making it extremely underpowered and inefficient. The non-pressurised carburettor fitted could not cope with the thin air at high altitude and it would be prudent to mention that if our American allies had not introduced the British to the higher octane derivative fuel that they used during WWII; Britain would have been left floundering and embarrassed.

When the Spitfire performed any -G manoeuvre, fuel was forced upwards to the top of the float chamber of that carburettor rather than into the engine. This led to a sudden loss of power. If that -G manoeuvre was sustained fuel collected in the top of the float chamber, forcing the float to the floor of the chamber. This would in turn open the needle valve to maximum, flooding the carburettor with fuel thus drowning the supercharger with an over-rich mixture. This would lead to a rich mixture cut-out, which would shut down the engine completely, a serious drawback in combat.

Pilots complained profusely regarding this fatal design flaw, and rightly so, requesting an immediate fix which came in the form of Miss Shilling's Orifice. A very simple technical device made to counter engine cut-out in early Spitfire and Hurricane fighter aircraft fitted with the same engine and used during the Battle of Britain. While it was officially called the R.A.E. restrictor, it was normally referred to under other various names, such as Miss Tilly's diaphragm or the Tilly Orifice in reference to its inventor, Beatrice "Tilly" SHILLING.

German fighters had fuel injected engines and therefore did not suffer from the same problems. Fuel injection pumps keeping fuel at a constant pressure regardless of the manoeuvres being made. German pilots exploited this advantage to the max and it was only the English RADAR that evened the playing field.

The Tilly orifice came into being when Beatrice 'Tilly' SHILLING, an engineer working at the Royal Aircraft Establishment at Farnborough came up with a simple device which could be fitted without taking the aircraft out of service. She designed a thimble-shaped brass flow restrictor (later further refined to a flat washer) with very precisely calculated dimensions to allow the flow of just enough fuel for the engine to develop maximum engine power. It came in two versions, one for a 12 psi and another for a 15 psi (supercharged unit) pressure manifold. While not completely solving the problem, the restrictor, along with modifications to the needle valve, permitted pilots to perform quick -G manoeuvres without the loss of engine power. This improvement removed the annoying drawback that Rolls-Royce Merlin powered fighters had in comparison to the German Messerschmitt Bf 109E which was fitted with a Daimler-Benz DB 601 inverted V12 powerplant complete with fuel injection since 1937 (it seems the Brits were a little slow on the up-take). Miss Shilling travelled with a small team around the countryside to one RAF base after another in early 1941 fitting the restrictors, giving priority to front-line units. By March 1941 the device had been installed throughout RAF Fighter Command. This simple measure was only a stopgap: it did not allow inverted flight for any length of time. The problem was not finally overcome until the introduction of the Bendix and later Rolls-Royce pressure carburettors in 1943 (still no fuel injection).

There were many variants of the Spitfire using several wing configurations, and it was produced in greater numbers than any other British aircraft manufactured at the time. It was also the only British fighter produced continuously throughout the war. The Spitfire continues to be popular among enthusiasts; about 54 remain airworthy, and many more are static exhibits in aviation museums throughout the world.

The spitfire's distinctive elliptical wing design by Beverley SHENSTONE was created to have the thinnest possible cross-section, helping give the aircraft a higher top speed than any other contemporary fighter of the day. The wing section used was a NACA 2200 series, which had been adapted to create a thickness-to-chord ratio of 13% at the root, reducing to 9.4% at the tip. Dihedral of six degrees was adopted to give increased lateral stability. Indeed, by accident a wing with a greater Mcr (critical Mach number) than that of a Supersonic F-111 was created.

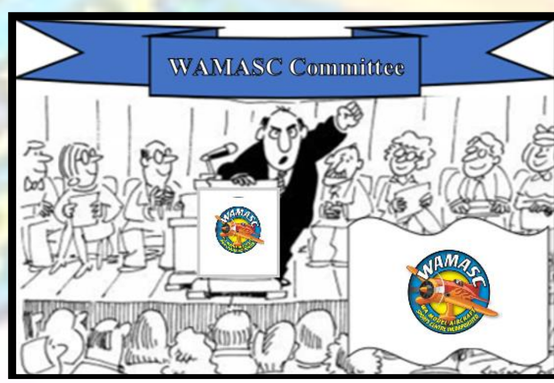
Despite its flaws the Spitfire will always be a thing of beauty worth romanticising over and my favourite.

And finally, what's in a design - the **Hawker Hurricane** (top right), evolved from the **Hawker Fury** (left). Designers and Engineers simply took an existing Biplane, the Hawker Fury, removed its upper wing and pimped it out beefing it up where required in preparation for combat service as a single wing fighter. I don't know if that's lazy or innovative – but it is another example of the British work around.

With the advent of WWII, the Hawker Hurricane was rushed into service prior to the Spitfire.

Although overshadowed in the public consciousness by the Supermarine Spitfire's role during the Battle of Britain in 1940. The Hurricane actually inflicted 60% of the losses sustained by the Luftwaffe in the engagement. The Hawker Hurricane went on to fight in all the major theatres of WWII.

COMMITTEE MESSAGE



A courteous and friendly reminder to all from the committee concerning the correct location for engine **start-up** and high-powered running. Please be mindful of **OH&S** (Occupational, Health & Safety) – especially the safety aspect(s) and requirement with engines. Particular focus and emphasis are directed toward **jet turbine engines** that can have the potential risk of disc failure (blade separation); a condition similar to a propeller failure. Should this occur with the nose of an aircraft pointing along a longitudinal axis in either an easterly or westerly direction in close proximity to the pits - the resultant of a disc failure is a projectile piercing the side of an aircraft and entering the pit area at high velocity. Please be mindful of all your fellow members safety and well-being. Umbridge is not intended in passing on this information – it is done so for the good of everyone.

A broken clock is correct twice a day