The phenomenon of stick-slip, also known as micro-stalling, is torsional vibration that occurs due to cyclical rotation acceleration and deceleration of the bit, BHA, or drill string. This speed fluctuation can be to zero RPM or far in excess of twice the rotational speed measured at the surface. While considerable damage may occur to the drill bit there is also the likelihood of damage or fatigue failure of other motor components. One of the most susceptible candidates for damage due to stick-slip is the Power Section stator.

During normal operation, bit rotation will be to the right if viewed from the drill floor. The bit torque generates an equal reactive torque that acts in the opposite direction. As the required bit torque increases, the reactive torque increases. Stick-slip occurs when there is an increased torque demand from the bit to achieve penetration that cannot be met by the drilling motor power section, causing bit rotation to slow or stop. This produces a sudden increase in reactive torque that is transmitted through the drill string as torsional vibration. Bit rotation is impaired until the drill string builds up enough torque to meet the required bit torque and resume penetration. The bit then breaks free, often at much higher speeds than normal due to the large amount of stored energy in the drill string.

The initial amount of rotational speed decrease depends on the output capacity of the drilling motor. If the required torque exceeds the full torque output capacity of the drilling motor it will stall. In stalled operation the power section is not able to maintain its sealing lines, so the drilling fluid passes through the stator without generating rotor rotation. Stick-slip also involves drilling fluid breaking the sealing lines within the power section. During either stick-slip or stalling, the reactive torsional loads transmitted through the stator are of a much larger magnitude than during normal operation due to the high differential pressure that is generated when the rotor slows or stops rotation.

Stick-slip causes uneven loading across the rotor/stator interface and repeated dynamic mechanical loading of the stator elastomer, causing surface wear and fatigue. This creates friction and heat, which is absorbed by the stator elastomer, and weakens elastomeric properties. This is commonly known as a heat aged elastomer. If heat is not dissipated within the elastomer it will swell the elastomer, causing increased rotor/stator interference fit, and subsequently more friction and heat.

Eventually, an elastomer that is heat aged or has a tighter than desired interference fit will fail. The typical mode of failure is chunking. Chunking is where small pieces of rubber break away from the stator liner due to the pressure exceeding the elastomer strength. A stator that has partially chunked will have a lower ROP due to increased leakage. Typically, an operator will increase WOB, causing more stick-slip and a faster elastomer failure rate. Once chunking has begun it will eventually spread throughout the stator until there are not enough sealing cavities to maintain speed and torque.

Stick-slip can be difficult to prevent but can be monitored and controlled to minimize damage to drilling components. Refer to the NOV Motor Handbook for causes, symptoms, and suggested solutions for stick-slip.