



FISK ALLOY, INC.

Technical Information



Bent Wire in Level Layer Winding

The phenomenon of bent square or rectangular wire near the barrel of layer level wound spools has been termed “Dogleg”. The phenomenon and its cause are herein discussed.

Definitions

Level Layer Wind: the spooling of wire wherein the wire lies directly adjacent and parallel to the preceding wrap of wire having been wound the width of the wire for each revolution of the spool from flange to flange. Level winding is done under tension and results in a smooth flat surface for each layer of wire so wound.

Traverse Winding: a winding pattern wherein the wire is wound across the face of the spool barrel at a rate greater than the size of the wire. Traverse winding results in an irregular surface and is realized using much lower tensions compared to Level Layer Wind.

Dogleg: a bend or kink in a square or rectangular wire found near the spool barrel. The kinks can be seen as a deviation from a straight line as the wire lies on the spool or when removed from the spool. Doglegs can occur in one or more layers of wire.

Turks Head Machine: a rolling mill utilizing one or more Turks Heads. A Turks Head for rolling square or rectangular wire is composed of four nested rolls. Turks Head rolls are not powered and require a powered capstan in front of them to pull the wire through the rolls.

Working Rolls: the nest of rolls in a Turks Head used to shape and reduce the size of the wire.

Wire Tension: the load (force) applied to the wire to pull the wire through the working rolls, straightener, winding onto the spool, etc.

Hoop Stress: the circumferential load placed on the spool barrel from the wire tension of each wrap of wire.

Cause

Doglegs form when the circumferential length offered by the spool barrel is shorter than the length of the wire wrapped around it. This happens when the supporting barrel contracts under the load of successive layers of wire wrapped around it (hoop stress). The excessive wire length relative to the barrel length seeks accommodation resulting in a sideways movement permanently deforming the wire into a “dogleg”.

Wire tension is required to run a Turks Head machine when producing square or rectangular wire. Level layer winding requires tension be placed on the wire to assure that it lies and stays flat in position on the spool when wound.

The amount of hoop stress imposed on a spool barrel is related to the wire tension and the number of wire wraps. By the increased number of wraps, smaller wires impose a higher total force on the spool creating greater hoop stress on the spool barrel. For example, one layer of 1.0 mm square wire comprising 150 wraps of wire per layer results in a much lower tendency to dogleg as compared to a 0.5mm square wire with 600 wraps in two layers for the same weight of wire and in particular when compared to a 0.25mm square wire which comprises 2400 wraps in four layers for the same weight of wire.

Shape change and size reduction of the wire through the working rolls generates substantial heat. A portion of this heat is carried by the wire. Heat in the wire can be substantially but not entirely dissipated prior to level layer winding. The wire wound on the spool cools down and contracts contributing to the hoop stress on the spool barrel.

Spool material and construction are critical. The very precision of level layer winding requires spools that are as uniform and accurate as possible. Plastic spools are best in this regards but they are most susceptible to degradation due to heat and cyclic stress. All plastic spools, however, are susceptible to causing dogleg.

As noted, without spooling tension wire can not be level layer wound. By the ever increasing diameter of the spool barrel from the wire wound onto it, spooling tension changes as the wire winds onto the spool. Thus spooling tension must be continuously monitored to realize the minimum tensions necessary to achieve level layer winding.

Corrective Action

Precision machined and trued steel spools could be a permanent corrective action for doglegs in level layer winding. However, the expense of these spools is financially prohibitive both in procurement and in the repeated freight cost of their tare weight. Both meeting with objections in the marketplace since the problem is not so pervasive as to warrant this expense.

Lacking precision steel reels the next best solution is to employ traverse winding where possible as it requires far lower tensions to effect.

Where level layer winding is required, Fisk Alloy Wire inspects and monitors spool cycles prior to use and effects continual oversight of spooling tension by the machine operators. Wire tension necessary for spooling is targeted to the minimum required to properly level layer wind the wire.

Fisk utilizes the best spools available to mitigate occurrence of dogleg. Search for ever stronger spools to withstand the necessary hoop stress with minimal deflection is an ongoing process and recommendations are made to customers as new spools become available.

However, it must be stated that absent of precision steel spools and with the next best alternative being plastic we can greatly reduce but not permanently eliminate the occurrence of doglegs when level layer winding.