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THE DIFFERENCE BETWEEN:

Machined Springs and Traditional Springs

A spiral of wire is the first image that comes to mind when you think of a spring. But the traditional method of spring production by winding wire is not the only way to make a spring. Machined springs have a similar helical form to traditional springs but with additional design flexibility, performance efficiency, and reliability.

Spring production

As their name implies, traditional wire-wound springs are made by forming metal wire or bar stock into a spiral shape. Manufacturers choose hot or cold forming methods depending on the material, the diameter of the wire or bar, and the desired properties of the finished spring. Common wire-wound spring materials include medium and high strength steels, nickel alloys, titanium, and stainless steels that gain their strength predominately from heat treating and cold reduction.

After the main forming operation, a wire-wound spring may have further shaping to the coil ends, shot peening to improve fatigue life, and zinc or nickel plating to boost corrosion resistance. Even with these secondary operations, production time for traditional springs is typically very short, contributing to the relatively low cost of this class of springs.

Machined springs start from bar stock that is precision machined into a cylindrical blank with one or more spirals of the desired pitch machined through its wall. Machining operations can also produce end attachments and stress-relief features.

Machined springs can be made from moderate to high-strength corrosion-resistant steel like 17-4 PH (AMS

Machined Springs cut from a single piece of material

5643), 15-5PH (AMS 5659), and CC 455 (AMS 5617); very high-strength steel like C300 (AMS 6514); nickel-chrome superalloys such as X750 Inconel®; aluminum (7075-T6 and 7068-T6511); and Beta C titanium. They can also be made from machinable plastics like Delrin® 100 and Ultem™ 2300.

With more emphasis on corrosion-resistant materials and tight-tolerance machining, machined springs take longer to produce and are more expensive per piece than wire-wound springs. However, they often can more efficiently address application challenges and last longer than wire-wound springs designed for the same task.

Design considerations

Engineers can design the performance of wire-wound springs by choosing the wire cross-sectional shape and dimensions, coil diameter, the number of coils, the distance between coils when unstressed, overall length, and wire material properties. Typically, spring rates for wire-wound springs can be dialed in to ±10%.

The end configurations of these springs can also affect performance. For instance, wire compression and extension springs typically experience unresolved bending moments due to the application of forces at a distance from the springs' centerlines. Bending, misalignment, rotation, and other boundary conditions can also affect the performance of wire springs.

Machined springs also allow design engineers to dial in performance by altering coil thickness, inside diameter, outside diameter, and the number of coils. For example, thicker coils handle greater torque and radial loads; inside and outside diameters affect torque capacity, torsional stiffness, and axial spring rates; and the number of coils changes linear and radial stiffness without affecting the torque capability. Design engineers can combine these parameters to meet their needs for high torque, angular or parallel misalignment, critical torsional stiffness, precise spring rates, and more in an efficient design envelope. Machined spring rates can have a precision of ±1% or tighter.

One feature that's only available with machined springs is multiple coil starts. Two or more intertwined flexures can

Some of the many Machined Spring Attachments

be machined into the same spring. Multiple coil starts can increase torsional stiffness and resolve bending moments during compression or extension to zero, providing a purely reactive force.

Another design option for axial machined springs is opposing right-handed and left-handed flexures machined into different sections of the same part to eliminate rotation at the spring ends during compression or extension.

Connection options

In many applications, the way a spring interacts with surrounding components is as integral to its performance as its basic design. Wire-wound compression springs can have a natural or clipped coil termination, a closed coil in which the last coil is nearly perpendicular to the spring's axis, or a closed and ground coil for improved perpendicularity and decreased wear. Wire extension springs usually feature a hook or loop to transmit the tensile force. In torsion springs, torque is applied to external, internal, or longitudinal tangs. Since the torque is being applied at a distance from the spring axis, additional provisions must be made to react to that component of the force.

Almost any kind of attachment can be integrated with a machined spring. Extension springs can incorporate pinholes, machined studs, threaded holes, flanges, and more. Likewise, a machined torsion spring can incorporate infinite attachment features, including machined tangs, slots, internal or external splines, or bolt circles to transmit a pure moment along the spring centerline.

Compression springs machined with precisely perpendicular ends reduce bending moments, or integral attachments can add functionality to the spring. For instance, a two-piece die spring that was failing unpredictably at the attachment point between the elastic element and the die component was replaced with a machined spring with an integral attachment, resulting in improved uptime and decreased maintenance cost and frequency. Other functional end pieces have included bearing seats, valve seats, gears, and bell-crank arms.

Conclusion

Springs machined from a single piece of material offer greater design flexibility than traditional wire-wound springs. Design engineers can tailor machined springs to meet an application's specific axial spring rate, torsional stiffness, or lateral bending requirements while fitting precisely into the design space and connecting robustly with adjacent components.

The wide-ranging capabilities of machined springs have led to their use in the aerospace, medical, precision equipment, and industrial arenas. Some examples of critical applications where machined springs have been useful include the Hubble telescope, cryogenic coolers, industrial knives, lasers, and aircraft electronics.

Machined spring experts at suppliers like MW Components can assist design engineers in developing custom machined springs to meet the needs of diverse applications requiring unique solutions.