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WHITE PAPER

Factors to Consider When Selecting a Raw Material for Disc Springs

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Disc Springs are ideal functional components for achieving consistent and predictable forces within specified distances of travel. Unlike other types of springs, including Belleville washers, Disc Springs have a predictable fatigue life which can be calculated. The reliability and predictability of these engineered, high-performance springs is unmatched. While Disc Springs look like a simple conical washer, the process to select the correct Disc Spring or Disc Spring Stack is quite technical.

Choosing the proper material for the Disc Spring is equally as important as selecting the proper size Disc Spring for your application. The reason being that the raw material factors are affected by:

1. **Force**
2. **Operating Environment**
3. **Fatigue Life**
4. **Cost**

Figure 1
Disc Springs are available in different types of materials. In this picture, Disc Springs are shown in carbon steel (left), and 17-7 stainless steel (right).

Below is an overview of the (4) aforementioned variables, and how each may affect the Disc Spring material selection.

Force

Generally, carbon and alloy steel Disc Springs perform the best because of their ability to be "springy". Carbon and alloy steel (otherwise known as spring steel) are also exceptionally durable and fatigue resistant when heat treated. Generally, you will see a greater force output (5-6% more) from a carbon or alloy steel Disc Spring as opposed to a 301 or 17-7 stainless steel counterpart in the same size. While spring steel can provide superior performance in an ordinary environment, its performance can begin to diminish at higher temperatures. Stainless steel Disc Springs provide better temperature resistance, but will not maintain their force output in extreme temperatures as well as exotic materials would such as Inconel Disc Springs. In situations where corrosion protection is desired, the design engineer should consider the cost-effect between using 2 or 3 stainless steel Disc Springs in parallel versus one carbon or alloy steel Disc Spring with mechanical zinc or ArmorGalv® (a zinc alloy thermal diffusion coating) - with both options achieving the same force.

Common Disc Spring Materials	Grade	Modulus of Elasticity
Alloy Steel	51CrV4 (1.8159) / UNS G61500	206 GPa
High Carbon Steel	C67S (1.1231) / UNS G10700	206 GPa
301 Stainless Steel	X10CrNi18-8 (1.4310) / UNS 30100	190 GPa
17-7 Stainless Steel	X7CrNiAl17-7 (1.4568) / UNS S17700	200 GPa
INCONEL® Alloy X-750	NiCr15Fe7TiAl (2.4669) / UNS N07750	214 GPa

Table 1

Operating Environment Considerations

The decision about selecting the raw material for the Disc Spring(s) can be quite complex when considering all of the parameters. Operating temperatures and potential for corrosion is a major factor in the material and/or coating selection.

For Example:

- In an aerospace application where extreme temperatures come into play, does an Inconel Disc Spring make sense? It might, however alternatively, you may consider using 17-7 stainless steel Disc Springs in a different configuration to achieve the desired performance in the assembly. Spring steel may not withstand corrosive environments. In this case, especially in dynamic applications, 17-7 stainless steel may be the best option.
- In braking systems, the need for longevity is paramount. Cleanliness is critical so that debris does not get into the brake line. Stainless steel, at first glance, appears to be the obvious choice. But what if in the application, the Disc Springs are submerged in hydraulic fluid? Uncoated carbon and alloy steel Disc Springs will have superior performance at a lower cost and the Disc Springs immersed in hydraulic fluid will be protected from corrosion.

Fatigue Life

The material choice of a Disc Spring affects the estimated fatigue life in an application. The biggest factor in the fatigue life of Disc Springs is how close the stress that is being placed on the Disc Spring is to reaching the tensile strength or yield strength of the raw material. The secondary factor is the difference between maximum and minimum stresses during cycling. Larger differences result in shorter fatigue life. Another important factor to consider is how the Disc Spring is being used in the application. Is the Disc Spring in a static, dynamic, or impact application? In a dynamic application, 300 series stainless steel will work harden and potentially have a shorter fatigue life compared to 17-7 stainless steel and carbon/alloy steel. The fatigue life of the Disc Spring(s) in the specific application should be calculated prior to making a final decision.

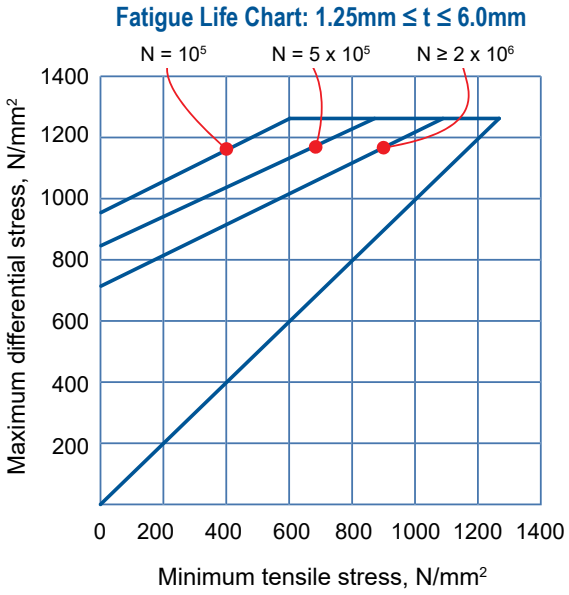

Figure 2
Estimated Fatigue Life for DSC 50 x 25.4 x 2 Disc Spring

Cost

It is obvious that the more exotic the raw material, the higher the cost will be for the Disc Spring. However, is cost the main driving factor? Will a more exotic material that lasts longer without the need for replacement be more cost-effective overall? Or, would a Disc Spring made from a commercially available standard material that would require replacement more frequently, still result in a lower overall cost based on the desired life of the assembly? Cost is not as simple as it may seem.

Conclusion

There are many factors to consider when determining the most appropriate Disc Spring raw material for a specific application. It is recommended that you work with Application Engineers who specialise in designing and manufacturing Disc Springs and Disc Spring Stacks to ensure the proper raw material is selected to achieve your desired technical and commercial requirements.

Complimentary Application Engineering Support

Need help choosing the most appropriate fastening solution for your application? SPIROL's Application Engineers will review your specific requirements, and help you select the most cost-effective Disc Spring to meet your technical and commercial needs. **Contact us today!**

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