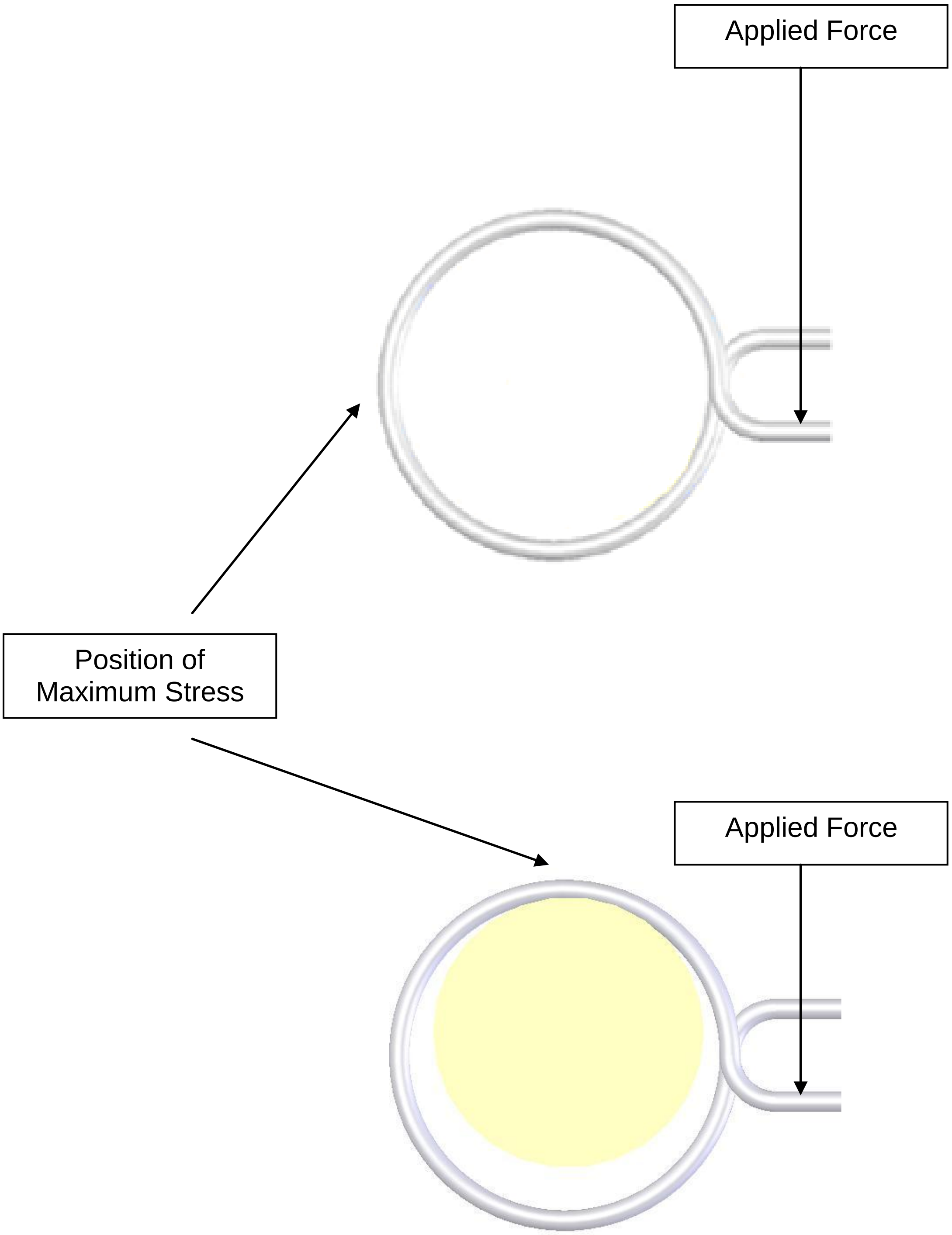
Cautionary Tale XXVII– Torsion Springs

Three separate case histories have been related to IST recently in which torsion springs have given a disappointingly low fatigue life. In each instance a fault with the raw material was suspected as the primary cause of the shorter than expected fatigue life. One of the springs was made from music wire, another oil tempered silicon chrome, and the final one was made from 302 stainless steel, but metallographic examination showed that all three wires were of good commercial quality.

However, IST observed that there were a number of common factors with these failures. All were definitely fatigue failures initiated at the outside surface of the spring. The fractures were at 180° from the point of load application. None of the springs had an effective mandrel to support the coils in use. CAD programs predicted that the springs should not have been at risk of fatigue failure at the given operating deflections. Often it is the interaction between the spring and its mandrel that leads to uncertainty about the fatigue life of torsion springs, and the need to test to evaluate fatigue life accurately.

Computer aided design programs for torsion springs assume that torque is proportional to stress, which is correct when a mandrel is in place. Without mandrel the lever length is significantly longer for a given torque and so the stress without a mandrel can be as much as twice as high, as shown in the diagram. The lever length is the distance between the applied force and the position of maximum stress.



The top figure represents a torsion spring with external radial legs, which is not supported on a mandrel. The stress is related to the induced moment within the body of the spring. The moment is equal to the product of the applied force multiplied by the distance from the point of application of the force to the position indicated as “Position of maximum stress”. This distance is equal to the radial leg length added to the outside diameter of the spring. Note that double torsion springs that operate without a mandrel should be treated as single torsion springs. Also torsion springs that are supported externally, often in a round housing, should also have stress calculated as if there is no mandrel.

The bottom figure represents a torsion spring with external radial legs, which is fully supported by a mandrel. The stress is related to the moment within the body of the spring. The moment is equal to the product of the applied force multiplied by the distance from the point of application to the force to the position indicated as “Position of maximum stress”. In this case this distance is equal to the radial leg length added to the radius of the spring.

For this case the fully supported spring will have approximately half the stress of the spring without a mandrel. The explanation for the shorter than expected fatigue lives and the moral of this cautionary tale is quite clear.

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