

Modeling the Creep Behavior of Torsional Springs

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Abstract: *A finite element model is developed to investigate the instantaneous as well as long-term (time-dependant) structural response of a pre-loaded torsional spring. Torsional springs belong to a class of spiral springs that are commonly made out of Elgiloy - an alloy of Cobalt, Chromium, Nickel and Iron. Elgiloy has very high yield strength, and is commonly used as a spring material in clocks. The research involves development of a detailed component-level model, using Abaqus/Standard, to investigate the instantaneous static moment-rotation response, and the long-term stress relaxation response of the spring system, along with, understanding the sensitivity of this response on the various design parameters. Frictional self contact, large deformation and nonlinear material behavior (plasticity and creep) are among the major challenges in solving this problem. The modeling effort also involves understanding the experimentally-observed hysteresis associated with the cyclic moment versus rotation response, and development of simple analytical models which can approximately describe the structural response of a typical torsional spring system with varying parameters.*

Keywords: *Aging, Creep, Freshly-Formed, Frictional Self-Contact, Hysteresis, Large-Deformations, Plasticity, and Torsional Spring.*

1. Introduction

Previous research conducted on elgiloy-based springs focused on measuring the properties of the elgiloy material (including creep) from a material science perspective (Assefpour-Dezfuly, 1984, 1985) and/or studies conducted on the load relaxation response of elgiloy based helical coil springs (Dykhuizen, 2004). There is little or no reference in the literature on the mechanical behavior and/or design of torsional springs.

Torsional springs are typically used to provide a certain value of torque for a specified rotation. The research presented here is part of a broader program that also has an experimental component (Lawton, 2007). However, experiments have their limitations in measuring the stress relaxation response over extended service lives--of the order of several years or decades. Furthermore, a large number of experiments would be needed to gain sufficient insight into certain aspects of the complex spring response, such as the dependence of performance on the coefficients of friction between the various contacting parts of the spring. Numerical modeling can provide some of the critical insights in this regard.