Property improvement of austenitic disc springs through targeted adjustment of residual stresses by means of incremental sheet forming

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ABSTRACT

Disc springs are shallow cone-shaped components with a wide range of applications in the industry. They are expected to have a long and reliable service life. However, operational tensile stresses can limit their lifetime. Conventionally, shot peening is used to induce the compressive residual stresses within tensile loaded areas to improve their fatigue behavior. The disadvantages associated with the conventional methods, like shot peening, are an increase in production time and costs.

In the current study, the incremental sheet metal forming (ISF) technique is applied for a targeted induction of the residual stresses within the disc springs. Springs are produced in two geometrical categories according to the DIN 2093 from AISI 301 and 316 stainless steel. The parameters of interest were spring characteristics i.e. spring force and residual stress stability of the disc springs at quasi-static and cyclic loading. Quasi-static and cyclic tests were carried out using a servohydraulic fatigue testing system and residual stress measurements were performed using the X-ray diffraction method. Furthermore, the effects of various ISF process parameters and strain induced martensite formation on residual stress content of disc springs were studied using finite element method. The Olson-Cohen (OC) model was employed for modelling the kinetics of the strain induced martensite transformation and the rule of the mixture of two phases was applied to specify the contribution of each phase on strength, i.e. γ austenite and α' martensite.

ISF method provided the possibility to integrate the residual stress induction within the forming process of disc springs. In this way, the additional shot peening process could be avoided. Compared to the conventionally-produced springs, the incrementally-formed ones display higher spring forces. The stability of residual stresses was increased notably with increasing the stress amplitude. These results were in accordance with the simulation results.

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