STRUCTURAL PERFORMANCE OF KAT-7'S BALL SCREW RACEWAY IN THE ELASTIC REGION SUBJECTED TO VARYING LOADS

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A dissertation submitted in fulfilment of the requirements for the degree
Magister Technologiae: Engineering: Mechanical
in the Faculty of Engineering and Technology

Vaal University of Technology

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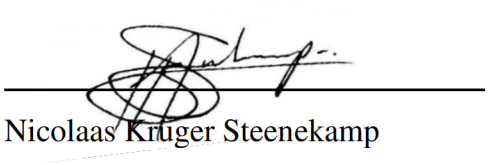
December 2017

Declaration

I, Nicolaas Kruger Steenekamp, student number 211077453 hereby declare that the following research information is solely my own work. This dissertation is submitted in fulfilment of the requirements for the degree Magister Technologiae: Engineering: Mechanical in the Faculty of Engineering and Technology at the Vaal University of Technology, Vanderbijlpark. This dissertation has never before been submitted for evaluation to any educational institution.



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15 December 2017

Acknowledgements

Through the Mercy and Grace of our Almighty God and Saviour, I received His guidance to complete a dissertation. The Beginning of Knowledge (Proverbs 1:7). I would like to express my gratitude to the following people and organisations that made the dissertation possible:

- My supervisor and co-supervisor Prof. Alfayo Alugongo and Prof. Leonard Masu
- Vaal University of Technology for their financial support

Dedication

This dissertation is dedicated to my family. To my loving wife Yolani and son Ralph, who supported and motivated me during the course of my research. Many late evenings, weekends and holidays were sacrificed to complete a dissertation. I thank them from the bottom of my heart for their unconditional love and unwavering support.

Abstract

The structural performance of a KAT-7's ball screw raceway is not known. No performance data has been generated analytically, numerically nor experimentally. For this study, data was generated in the elastic region of the material. This research was undertaken in three different ways namely analytically, numerically and experimentally. A calibrated load cell was used to validate the analytical solutions. Solid Edge, a parametric software package was used to validate analytically the accumulated rain water mass and structural mass. Abaqus, a finite element analysis software package, was used to model and obtain the ball bearing Hertzian contact stresses numerically. The numerical solution was used to validate the laboratory compression test results on a replica KAT-7 ball screw assembly. The weighted percentage errors between the analytical model data and load cell data were found to be higher for load case scenarios with zero m/s and 10 m/s wind speeds respectively. The parabolic reflector rigid body assumption, exclusion of wind induced hysteresis effects and the quasi-static wind loading site measurement conditions contributed to the weighted percentage error variations. The laboratory and numerical model compression force results revealed a gradual percentage error increase beyond a compression force of 261288 N and up to 572526 N. The percentage error increase had minimum and maximum errors ranging between 6.24 percent and 14.69 percent respectively. The percentage error increase in the numerical model was due to the singular representation of a ball bearing instead of a 212 ball bearings set as experimentally conducted in the laboratory compression test on a replica KAT-7 ball screw assembly. The maximum axial force, F_0, result for load case scenario five was -94469 N with a Hertzian contact stress of 3939 MPa on the raceway surface. The static load rating required to Brinell a deep groove ball bearing raceway was found to be a Hertzian contact stress ranging between 4500 MPa and 4800 MPa. It was evident that the contact stresses incurred under the three considered loads of accumulated rain water, wind loading and structural mass were unable to exceed the 4800 MPa Hertzian contact stress. It was found that a replica KAT-7 ball screw raceway Brinelled under an axial force of 408126 N. The numerical ball screw raceway model Brinelled under an axial force of 380457 N. The Hertzian contact stress at the numerical ball screw raceway surface was determined to be 4898 MPa. Therefore, the Replica KAT-7 ball screw raceway material behaves elastically under an approximate load of up to 38 tonnes.

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