

**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



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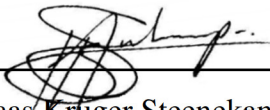
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**December 2017**

## 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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Nicolaas Kruger Steenekamp

15 December 2017

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## **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.

## Table of Contents

Declaration	i
Acknowledgements	ii
Dedication	iii
Abstract	iv
Table of Contents	v
List of Figures	viii
List of Tables	xi
List of Annexures	xii
Glossary and abbreviations	xiii

### **CHAPTER 1: INTRODUCTION** **1**

<b>1.1</b>	<b>Background</b>	<b>1</b>
<b>1.2</b>	<b>Problem Statement</b>	<b>2</b>
<b>1.3</b>	<b>Research Objectives</b>	<b>2</b>
<b>1.4</b>	<b>Limitations of the Research</b>	<b>3</b>
<b>1.5</b>	<b>Significance of the Research</b>	<b>4</b>
<b>1.6</b>	<b>Overview of Chapters</b>	<b>4</b>

### **CHAPTER 2: LITERATURE REVIEW** **5**

<b>2.1</b>	<b>Introduction</b>	<b>5</b>
<b>2.2</b>	<b>KAT-7 Overview</b>	<b>5</b>
2.2.1	Project background	5
2.2.2	Main assemblies	5
2.2.3	Axis systems	7
2.2.4	Mechanical articulation	8
2.2.5	Ball screw overview	9
2.2.6	Ball screw force translation	11
<b>2.3</b>	<b>Wind Loading on Paraboloidal Surfaces</b>	<b>12</b>
<b>2.4</b>	<b>Static Axial Load Rating</b>	<b>13</b>
<b>2.5</b>	<b>Tension and Compression Tests</b>	<b>13</b>
<b>2.6</b>	<b>Hertzian Contact Stress</b>	<b>18</b>
<b>2.7</b>	<b>Brinelling and False Brinelling</b>	<b>18</b>

<b>2.8</b>	<b>Numerical Modelling</b>	<b>20</b>
<b>2.9</b>	<b>Available approaches relevant to this research</b>	<b>22</b>
<b>2.10</b>	<b>Conclusions</b>	<b>23</b>
 <b>CHAPTER 3: RESEARCH METHODOLOGY</b>		 <b>24</b>
<b>3.1</b>	<b>Introduction</b>	<b>24</b>
<b>3.2</b>	<b>Ball Screw Materials Examination</b>	<b>24</b>
3.2.1	Material samples	24
3.2.2	Chemical analysis	25
3.2.3	Spectrometric analysis	25
3.2.4	Vickers hardness	25
<b>3.3</b>	<b>Analytical Model Load Case Scenarios</b>	<b>26</b>
<b>3.4</b>	<b>Analytical Modelling</b>	<b>27</b>
3.4.1	Analytical force, $F_0$ , solution	27
3.4.2	Accumulated rain water mass	39
3.4.3	Wind loading	46
3.4.4	Structural mass	53
<b>3.5</b>	<b>Load Cell Data Acquisition</b>	<b>54</b>
<b>3.6</b>	<b>Validation of Obtained Force Data</b>	<b>56</b>
<b>3.7</b>	<b>Compression Testing</b>	<b>57</b>
3.7.1	Assembly steps of a replica KAT-7 ball screw	57
3.7.2	Compression test procedure	61
<b>3.8</b>	<b>Numerical Modelling</b>	<b>63</b>
3.8.1	Finite element model geometry	63
3.8.2	Model material selection	64
3.8.3	Model element selection	64
3.8.4	Simulation load selection	66
3.8.5	Boundary conditions modelling	66
3.8.6	Output	66
<b>3.9</b>	<b>Conclusions</b>	<b>67</b>
 <b>CHAPTER 4: RESULTS, DISCUSSION AND CONCLUSION</b>		 <b>68</b>
<b>4.1</b>	<b>Introduction</b>	<b>68</b>
<b>4.2</b>	<b>Ball Screw Materials Examination Results and Discussion</b>	<b>68</b>

4.2.1	Chemical composition and hardness of the spindle	68
4.2.2	Chemical composition and hardness discussion of the spindle	69
4.2.3	Chemical composition and hardness results of the nut	71
4.2.4	Chemical composition and hardness discussion of the nut	72
4.2.5	Chemical composition and hardness results of the ball bearings	73
4.2.6	Chemical composition and hardness discussion of the ball bearings	74
4.2.7	Materials examination conclusion	74
<b>4.3</b>	<b>Analytical Model Load Case Scenario Selection Results and Discussion</b>	<b>76</b>
4.3.1	Analytical model load case scenario selection results	76
4.3.2	Analytical model load case scenario selection discussion	77
<b>4.4</b>	<b>Analytical Model Data and Load Cell Data Verification</b>	<b>79</b>
4.4.1	Force, $F_0$ , and, $F_a$ , results of load case scenario one	79
4.4.2	Force, $F_0$ , and, $F_a$ , discussion of load case scenario one	81
4.4.3	Force, $F_0$ , and, $F_a$ , results of load case scenario two	82
4.4.4	Force, $F_0$ , and, $F_a$ , discussion of load case scenario two	84
4.4.5	Force, $F_0$ , results of load case scenario three	85
4.4.6	Force, $F_0$ , discussion of load case scenario three	87
4.4.7	Force, $F_0$ , results of load case scenario four	89
4.4.8	Force, $F_0$ , discussion of load case scenario four	90
4.4.9	Force, $F_0$ , results of load case scenario five	91
4.4.10	Force, $F_0$ , discussion of load case scenario five	92
<b>4.5</b>	<b>Compression Test and Numerical Model Results and Discussion</b>	<b>93</b>
4.5.1	Compression test data and numerical model data results	93
4.5.2	Compression test data and numerical model data discussion	98
<b>4.6</b>	<b>Conclusions</b>	<b>99</b>
 <b>CHAPTER 5: CONCLUSION AND RECOMMENDATIONS</b>		<b>100</b>
<b>5.1</b>	<b>Introduction</b>	<b>100</b>
<b>5.2</b>	<b>Conclusions</b>	<b>100</b>
<b>5.3</b>	<b>Recommendations</b>	<b>105</b>
 <b>REFERENCES</b>		<b>106</b>